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# PUNCH AND BEAUTY



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# Telephone Answering Breakthrough

*Let a new remote control answering computer free you from your next telephone call.*



It's a telephone answering computer. The Ford 820 has the first large-scale integration of solid-state componentry which marks a major change in telephone answering systems since the first mass consumer models appeared five years ago. This means more features, lower cost and greater dependability. Here are some of its exciting features:

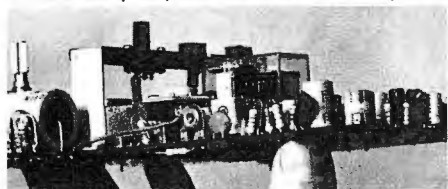
**Forget about tapes** There are no tapes to buy. The Ford unit has a special polymer-based magnetic tape that will record over 25,000 phone calls without replacement. That's over five solid years of use. There are no cassette tapes to buy, wear out or replace.

**Forget about microphones** When you want to change or record your message, just press a red button, record your message and let go. The message (any length up to 30 seconds) will record and be immediately ready to playback since the message tape does not have to recycle. There are no separate microphones or level controls since the built-in microphone automatically adjusts to your voice.

**Forget about touching it** You can adjust your unit to answer on either one or four rings. When the unit is set on four rings and you reach the phone before the 820 answers, you will not activate the unit. But let us say you're outside or indisposed. No problem. The Ford 820 will automatically answer after four rings. This means that your unit can always be "alive" in the four-ring position so you never have to remember to set it whenever you leave your home or office.

**Forget about going home** Just bring your optional remote control pager with you. If you want your messages while you're on vacation or away, call your number and the coded pager will remotely signal your unit to playback all your messages.

**Forget about service** If you've owned a telephone answering device for more than a year, there's a good chance that it's been in for service at least once. The Ford unit, however, is solid state and built with the same heavy duty components Ford uses in its commercial unit. It should dependably stand up to years of heavy usage. (Ford Industries is the world's largest supplier of telephone answering equipment for the Bell system.) If service is ever required, there are over 200 authorized service centers plus a service-by-mail center. There's also a toll-free "Help-Line" number to call 24 hours a day for advice or suggestions, and your unit has a limited one year parts and labor warranty.



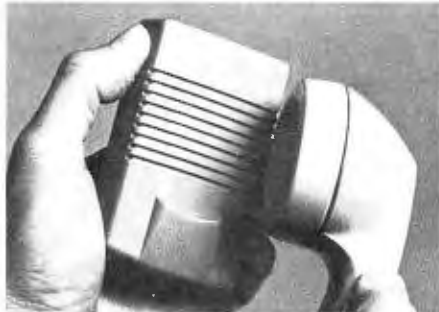
*The entire printed circuit-board with its integrated circuits is easily replaceable and contains the "Brains" required to control the audio amplifier and tape transport system.*

## PLENTY MORE FEATURES

The Ford 820 has a monitor feature—you can listen to the caller leave his message and pick up the phone to intercept the call. If you want to skip over a message on the tape, just tap a button and it fast-advances to the start of the next call. It has a selectable erase feature that lets you erase a specific message or the entire tape if you wish.

## KNOW HOW MANY CALLS

With other answering machines, you never know how many calls you receive until you play them back. With the Ford 820 you have a call counter—a device that displays the exact number of calls you've received when you arrive home. If you now own another answering machine, you can really appreciate this convenient and exclusive feature.



*Hold the small pocket-sized remote-control pager up to any telephone in the world and you can playback all your messages.*

The Ford unit is the first really versatile answerer that works equally well at home or in the office. It's perfect for the busy or working housewife who spends little time at home. And, if she's home and just plain busy when the phone rings, she can always call back later without offending the caller.

The executive can now leave his office, call from the field and get all his messages. An inefficient operator at a telephone answering service may offend your customers by putting them on hold. The Ford 820, however, takes your message quickly—without delay.

There are very few people who haven't left a message on a telephone answering machine, and callers really appreciate the convenience.

## NO PHONE COMPANY TARIFFS

The Ford unit is equipped with an FCC-approved interconnect device so your unit is actually welcome on your phone line. The 820 comes with a four-pronged plug so you just plug it into your phone jack. If you don't have a phone jack, just call your phone company and tell them you are purchasing an approved Ford unit and that you want a four-pronged jack for your phone. They'll know exactly what you want and charge you around \$12 for the installation, depending on where you live. If you have a multi-line phone, they can install a jack to tie into any or all of the lines you wish. There are no additional monthly charges.

## STANDING BEHIND A PRODUCT

JS&A lets you use the 820 in your home or office for one full month. Use it to screen your calls, take messages while you're gone or as a back up system when you're busy. Use the remote pager and retrieve calls while you're out. See how easy it is to change the message in seconds, and see how much it uncomplicates your life. Use it under your everyday conditions at home or at your office and then decide after one month whether or not you want to keep it. If you decide to keep it, you'll own the best. If not, return your unit for a full and prompt refund. There is no risk. Even if you already own a phone answerer, it would pay for you to see how much better the 820 performs.

JS&A is America's largest single source of space-age products and a substantial company—assurance that your purchase is protected.

The Ford 820 comes in two models: the Remote Control unit for \$259.95 called the 820P and the same unit without the pager but with all the other features for \$179.95 called the 820S. Simply select the unit you want and send your check for the correct amount to the address shown below. Credit card buyers may phone in their orders by calling our toll-free number below. (Illinois residents add 5% sales tax.) There are no postage and handling charges.

By return mail, you'll receive the Ford unit complete with all connections and instructions (and pager with remote unit) plus your one year limited parts and labor warranty. The unit measures 3 1/4" x 8 1/2" x 12" and weighs six pounds.

The Ford 820 compares to units that sell for much more but do not have the simplicity and the advanced electronics. Don't be confused. The Ford 820 is the finest telephone answerer you can buy at any price and is years ahead of all other conventional systems.

JS&A gives you everything you could possibly expect from a telephone answering system: 1) A unit years ahead of every other unit at a very reasonable price. 2) A service network that covers the United States with repair centers and free telephone assistance. 3) The chance to buy a unit in complete confidence, knowing that you may return it without being penalized with a postage and handling charge if it's not exactly what you want. You can't lose.

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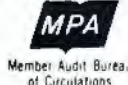
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## Editorial

### TV FOR RADIO AMATEURS

Amateur TV (ATV) experimenters are a hardy group. For decades now, a small number of hams have been working with on-the-air television, enjoying high-quality video. With the lowering of TV camera prices, and the availability of relatively inexpensive surplus equipment that can be modified for use in the 420-MHz ATV band, more hams are taking a closer look at this interesting communication area.

As many readers know, there's a wide difference between the bandwidth of a single channel of ATV and one of slow-scan TV. The narrow-band SSTV system used in the 14-MHz and hf and vhf bands require about eight seconds to "paint" a full, low-resolution picture on the face of a CRT. In contrast, ATV video has virtually an instantaneous format with commercial TV standards. Unlike SSTV, however, ATV has a fairly short communication range due to its restriction to uhf amateur bands. Consequently, the virtue of commercial-TV picture quality is countered by the absence of long-distance contacts. Therefore, it's interesting to note that a petition was filed with the FCC this year for establishing a new community educational radio fixed service (CERFS), called "Communicating," that proposes the use of frequencies in the 470-to-930-MHz band, preferably commercial TV channels from 70 through 83. It's conceivable that hams could assist legitimate agencies to transmit if such a proposal is ever adopted. This would certainly spark the growth of ATV, as well as build a pool of technically trained "communicasters."

The petition outlines the use of repeaters to cover communities for educational and public service purposes, emphasizing the cost effectiveness of such a service in the vhf/uhf region as compared to the established "Educational Radio Service" in the 2.5-to-2.69-GHz band, where equipment costs are prohibitively high. The proposal cites an example of two-way communication for educational purposes that was carried out by a medical college.

The proposal—spearheaded by Ed Pillar (W2KPQ), an active ATV'er, and Dr. Lee Cohen (WA2RPC), an educator—is certainly an interesting one. Since most of the allotted uhf channels around the country are not used, the resource would not be wasted. On the other hand, broadcasters and cable-TV operation would doubtlessly object.

There are local educational and public service audio/video communications that will probably never be attempted by professional broadcasters, of course. I cite local school board budget meetings, as an example. Could or should this type of telecasting be effected on existing uhf channels? It would clearly be an efficacious way to bring "communicating" to local communities, although the logistics problems that would ensue could be most challenging. Or, alternatively, should another frequency band, below the gigahertz one, be allotted for the aforementioned purposes?

You can express your comments (an original and five copies) on the proposal (petition No. RM-2846) by June 13 to the Federal Communications Commission, Washington, DC 20554.

*Art Salsberg*



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# Letters

## SWAMPFELDER STRIKES AGAIN!

In the "April Hobby Scene," you have casually dropped a scientific bombshell! Marcia Swampfelder describes a device called the "in situ" solar cell. This story, if true, is the economic equivalent of "How to Turn Sand Into Gold for a Few Dollars and a Day's Work." In one fell swoop, it obsoletes 65 million dollars worth of 1977 ERDA contracts for solar cell research. However, it has a certain hoax-like quality to it. I'm no chemist, but after diagramming the molecule for the long-named "reactive agent" described, I get something that looks a lot like common motor oil.—Clyde R. Smith, Fort Worth, TX.

Marcia Swampfelder's masterful ideas appear only in April each year, brimming with the spirit of April Fool's Day. The low-cost solar cell described was simply one of the many implausible items presented.

## ALTAIR MONITORS

Regarding your article about computer monitors ("Computer Bits," April 1977): (1) The 680b Monitor was not written by Micro-Soft, as stated. It is a highly modified version, developed by MITS, of Motorola's Minibug. (2) The modifications required to run software written for Mikbug with the 680b Monitor are

trivial, especially since a source listing of the monitor is included with the Altair 680b computer. Thus, there is no reason to run anyone else's software on the 680b.—Mark Chamberlin, MITS, Albuquerque, NM.

## DON'T SILENCE SOME RADIOS

The article "Build a Silencer" (March, p 57) contains instructions that will cause malfunction and possible damage if applied to certain GM-Delco radios. Our newest AM/stereo FM radio and tape combination units use bridge audio IC's that do not use chassis ground for the speaker system, nor do they share a common speaker return. Each audio channel is served by a separate IC, with two wires to each ungrounded speaker. The modifications proposed in the article would tie the IC modules together and cause extreme distortion, high current drain, and might permanently damage the bridge IC modules. The Silencer should not be used with the bridge audio circuits in our 1976 and 1977 stereo radio and tape products.—David A. Cox, Delco Electronics, General Motors Corp., Kokomo, IN.

## "MORSE-A-LETTER" BOOSTER

I have nothing but praise for the "Morse-A-Letter" project (January 1977). I built my project from the very reasonably priced kit supplied by Select Circuits. I must say that this was the most enjoyable and well-presented project I have come across. When I called Mr. Sievert for some help on a problem I encountered (my own fault), I was impressed with his attitude and interest. I wish more company representatives had the same attitude toward customer satisfaction. I highly recommend the "Morse-A-Letter" and the Select Circuits kit to anyone who wants a great project.—Robert F. Miller, Walcottville, IN

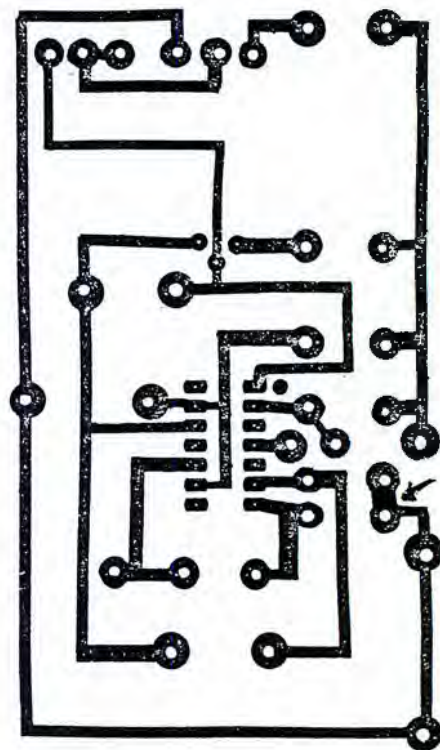
## OF "ELVES" AND COMPUTERS

The "Cosmac 'Elf'" microcomputer construction article (August 1976) must be your best project yet. I am in the process of upgrading to 4k memory, and I am planning to add a cassette tape interface. Also, keep those Computer Bits columns and programming articles coming.—Stanley W. Pozerski, Jr., Lowell, MA.

# Out of Tune

In "Westminster Clock" (November 1976), the point labelled H in Fig. 3 should be connected to pin 13 of IC19 in Fig. 1 (not to pin 6 as shown). Also, if you are unable to find the specified displays for DIS1 through DIS4, you can substitute Radio Shack No. 276-065 fluorescent display tubes.

In "A/D Temperature Converter" (December 1976), there is an error in the etching and drilling guide shown in Fig. 2 in the area of D1, R7, and R8. The corrected guide is shown below.



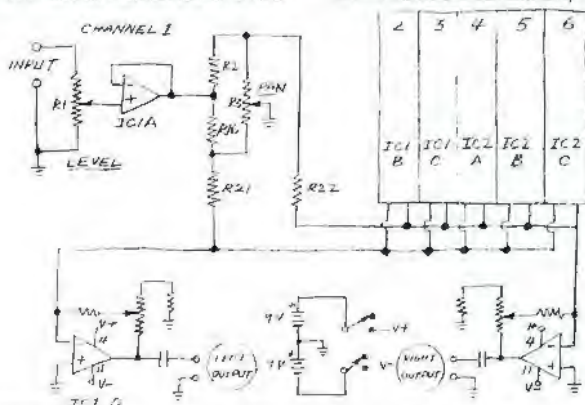
In "Build a 10-Hz to 1-MHz Eput Meter" (March 1977), the values of resistors R5 and R8 are specified incorrectly in the Parts List. (They are correct on the schematic.) They should be, respectively, 22,000 and 10,000 ohms.

In "LED Racing Game" (March 1977), the foil traces for the V<sub>CC</sub> pads (pins 16) of IC6, IC7, and IC8 are missing from the etching and drilling guide in Fig. 6. Connect these pads directly from the V<sub>CC</sub> bus to the pin-16 pads exactly as shown for the IC5 location.

## BUILDING A BETTER PAN/MIXER

In the Pan/Mix article (October 1976), it was stated that the INPUT LEVEL potentiometer presents a constant 10,000-ohm resistive load on the output of the signal sources. This is incorrect, since the input resistance depends to a great extent on the settings of the INPUT LEVEL and PANNING controls. The highest possible resistance is indeed 10,000 ohms, but only when the INPUT LEVEL control is at minimum; the lowest resistance of 3750

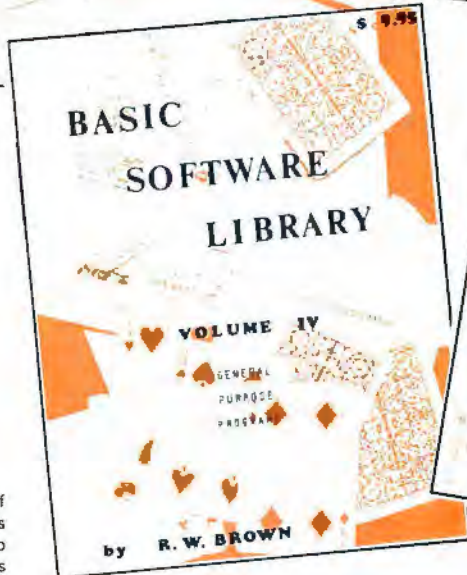
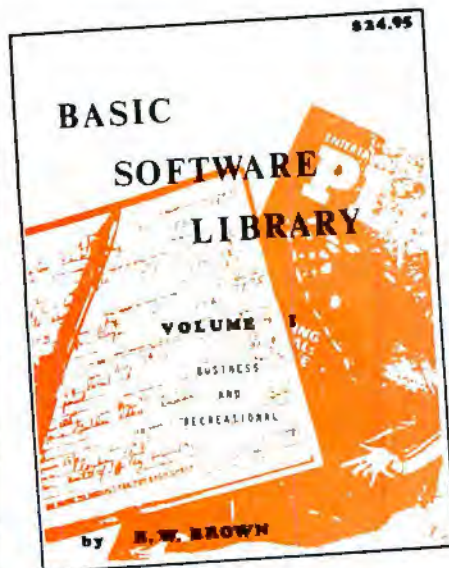
ohms occurs when the control is all the way up. To overcome this problem, I have devised a circuit (see schematic diagram) that can be added to the project. By using two low-power quad op-amps, such as the LM324, it is possible to have six input channels, keep the supply current to a minimum, and maintain a constant 10,000-ohm input resistance. Since the input bias current is only 0.25  $\mu$ A maximum, the op-amp does not present any loading effect on the INPUT LEVEL potentiometer.—Richard DeLombard, Toledo, OH





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EXPERIMENTER

This library is the most comprehensive work of its kind to date. There are other software books on the market but they are dedicated to computer games. The intention of this work is to allow the average individual the capability to easily perform useful and productive tasks with a computer. All of the programs contained within this Library have been thoroughly tested and executed on several systems. Included with each program is a description of the program, a list of potential users, instructions for execution and possible limitations that may arise when running it on various systems. Listed in the limitation section is the amount of memory that is required to store and execute the program.

Each program's source code is listed in full detail. These source code listings are not reduced in size but are shown full size for increased readability. Almost every program is self instructing and prompts the user with all required running data. Immediately following the source code listing for most of the programs is a sample executed run of the program.

The entire Library is 1100 pages long, chocked full of program source code, instructions, conversions, memory requirements, examples and much more. ALL are written in compatible BASIC executable in 4K MITS, SPHERE, IMS, SWTPC, PDP, etc. BASIC compilers available for 8080 and 6800 under \$10 elsewhere.

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## New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

### TECHNICS OPEN-REEL DECK

The Technics Model RS-1500US "isolated loop" direct-drive tape deck is said to isolate completely the tape loop from all outside influences such as take-up and back tensions exerted by the reels. The loop is driven directly by a 3.6 rps dc motor (at tape speed of 15 ips) locked to a quartz-crystal servo circuit.



Wow and flutter is 0.018% W rms. The head configuration includes a 4-track playback head, 2-track erase, 2-track record, plus 2-track playback. Other features include separate three-way adjustments of recording bias and equalization, average-reading VU meters that also indicate playback levels, timer for unattended recording, and edit dial (just below the heads) that simplifies editing and splicing. Maximum reel size is 10½ in., and speeds are 15, 7½, and 3¼ ips. Measures 18"W x 17½"H x 10½"D (45.6 x 44.3 x 25.7 cm). \$1500.

CIRCLE NO. 89 ON FREE INFORMATION CARD

### E.F. JOHNSON AM/SSB CB TRANSCEIVER

E.F. Johnson's new 40-channel Viking 4740 mobile CB transceiver features both AM and SSB operation, LED numeric channel display, and color-keyed indicator lights for mode selection (AM, USB, LSB). The display also features a dimmer switch for subdued nighttime use. Other features include an illuminated S/r-f meter, built in and switchable noise blanker, and PA function. A crystal lat-



tice filter is said to provide a high degree of adjacent-channel rejection. On transmit, a speech compressor increases average modulation levels. The clarifier or "fine-tune" control is claimed to have exceptionally smooth operation and a center-notch position for easier adjustment. \$359.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

### SUPEREX POWER MICROPHONE FOR CB

Superex's Model PV-1 CB power microphone features an electret cartridge and a self-contained FET preamplifier and power amplifier.



The single 1.5-volt penlight cell that powers the amplifiers comes with the mike. A special no-solder connector is supplied for attachment of the mike to CB transceivers. Also provided with the mike are a 6' (1.8-m) coiled cord and complete installation instructions. \$34.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

### MITSUBISHI POWER AMPLIFIERS

Mitsubishi is marketing two "dual-monaural" (stereo) power amplifiers said to have better than 80-dB channel separation. Models DA-A10 and DA-A15 are rated at 100 and 150 watts/channel, respectively. They are designed to be "docked" with the company's Model P10 dual-monaural preamplifier or Model M10 power level meter. According to Mitsubishi, the dual-monaural scheme effectively eliminates crosstalk while improving channel separation by as much as 30 dB or more over conventional designs. Both amplifiers feature high-capacity separate power supplies, wide dynamic response and range, distortion-reducing circuitry, special heat sinks, and circuits to protect against low-load impedance and dc potentials. Model DA-A10, \$390; Model DA-A15, \$590.

CIRCLE NO. 100 ON FREE INFORMATION CARD

### HUSTLER CB BASE-STATION ANTENNA

New-Tronics' Model HP-27 Hustler "Homing Pigeon" CB base-station antennas are for operation in places where outside antennas are either impractical or prohibited. No installation is required. The antenna is supported between the floor and ceiling of a room in the same manner as a pole lamp. Performance is said to be equal or superior to the best mobile antennas. Two free-sliding sleeves quickly



and easily adjust the antenna to resonance and optimum SWR. Once adjusted, the SWR is said to be well below 2:1 over the entire 40-channel CB range. The antenna is supplied with 17' (5.2 m) of coaxial cable to which connectors are attached at the factory. \$42.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

### AEC FUNCTION GENERATOR

Available in both kit and wired forms, the AE Corp Model 21 function generator offers a 1-Hz to 1-MHz range with 5% accuracy and 200 ppm/°C stability. Sine, square, and triangle output waveforms are switch selectable. The output is continuously variable from 0 to 20 volts p-p open-circuit (10 volts p-p into 100 ohms) and can be dc offset by as much as ±10 volts. There are also separate fixed 5-volt TTL square-wave and 4-volt p-p triangle-wave outputs. In addition, the generator features external frequency control vco with a range from dc to 1 MHz. External control also permits the instrument to deliver FSK (frequency-shift keyed), FM, and tone-burst modulated signals at the output. \$124.95 wired, \$79.95 kit.

CIRCLE NO. 94 ON FREE INFORMATION CARD

### BURWEN DYNAMIC NOISE FILTER

The new Burwen Model DNF 1201A dynamic noise reduction system is said to provide up to 30 dB of noise reduction at 10,000 Hz with 5 to 14 dB of overall hiss reduction. A bandwidth controller circuit measures the high-frequency content of the sum of the left and right inputs from the source material and adjusts





# Want maximum CB performance? You'll know you're exactly "on-channel" with B&K-PRECISION's NEW FREQUENCY COUNTER!



B&K-PRECISION Model 1827  
**\$120\***

For the serious CBer, the 1827 and accessory signal tap provides digital readout of transmit frequency, mobile or base on all 40 channels. For best range and signal clarity, your transmitter should be operating exactly on the assigned channels. The only way to accurately check this is with a frequency counter.

The new B&K-PRECISION Model 1827 is a full-feature battery portable frequency counter for only \$120\*. Not much larger than a pocket calculator, the 1827 offers six-digit LED display and guaranteed operation to 30 MHz with 1 Hz resolution. Other features include a unique battery saver that turns off the display after 15 seconds, and autoranging or "1 second" operation. In the 1 second position, you'll get 1Hz resolution for eight-digit accuracy.

When used with the optional SA-10 signal tap, you'll be able to use the 1827 to constantly monitor the out-

put frequency of your CB or ham transceiver, up to 100 watts, without affecting performance. Other accessories include: mobile and ac adapter/chargers, nickel cadmium batteries, under-dash mounting bracket, portable antenna and leatherette case.

With the 1827 you'll always be sure that you're exactly "on-channel" for maximum range. It's like having a technician check your rig every time you transmit!

\*Suggested retail price, less accessories.

*For the complete story, contact your  
B&K-PRECISION dealer or write:*

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CORPORATION**

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the bandwidth in accordance with both level and frequency. Dynamic filtering is achieved as the bandwidth controller generates dc control voltages to constantly regulate the cutoff frequency of the filter. The low-pass filter's cutoff frequency varies between 500 and 30,000 Hz, in accordance with source requirements. Attenuation rate is 9 dB/octave, and claimed dynamic range is 96 dB. The system operates without requiring encoded signals and is designed to selectively reduce noise without destroying fidelity or high-frequency content.

CIRCLE NO. 95 ON FREE INFORMATION CARD

### ELAC BELT-DRIVEN TURNTABLE

The Model PC 830 is Elac's first belt-driven turntable. It features idler-wheel assist for start-up and cycling, two pushbuttons for simplified operation in either the single-play or the multi-play modes, new low-mass tone-



arm, and illuminated stroboscope. The idler wheel assist brings the massive 4.4-lb (2-kg) platter up to speed quickly. The anti-skating control is calibrated separately for conical, elliptical, and CD-4 styli. Operating speeds are 33 $\frac{1}{3}$  and 45 rpm, both of which can be adjusted by up to  $\pm 3\%$  with a vernier control. Wow and flutter are DIN rated at 0.08%, rumble at better than 44 dB unweighted (64 dB weighted). Tracking error is rated at less than 1.4°. Size is 17 $\frac{1}{8}$ "W  $\times$  13 $\frac{3}{4}$ "D  $\times$  6 $\frac{1}{8}$ "H (43.5  $\times$  35  $\times$  17.5 cm). Supplied with automatic and manual spindles, the turntable sells for \$189.95.

CIRCLE NO. 96 ON FREE INFORMATION CARD

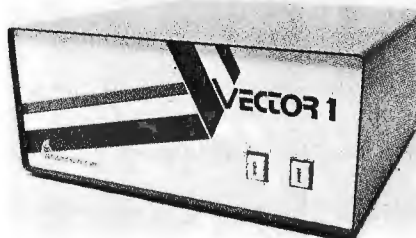
### SPARKOMATIC DELUXE CB BASE STATION

The 40-channel Model CB-1500 AM CB base station from Sparkomatic Corp. features a PLL digital frequency synthesizer, seven-segment LED channel display, and ac/dc operation. The deluxe station includes continuously variable fine tuning, tone control, r-f gain control, noise blanker (NB) switch, automatic noise limiter (anl) switch, and an SWR indicator. Other features include: illuminated modulation-percentage meter, S/r-f meter, transmit/receive/antenna-warning indicator lights, and a headphone jack, PA function switch and external speaker jacks. The built-in, 5-in. speaker faces front. The transceiver is housed inside a solid teak wood cabinet.

CIRCLE NO. 97 ON FREE INFORMATION CARD

### VECTOR GRAPHIC MICROCOMPUTER

The Vector 1 microcomputer from Vector Graphic Inc. comes in a custom cabinet that contains an 18-slot, 100-point motherboard with six connectors, power supply (8 volts at

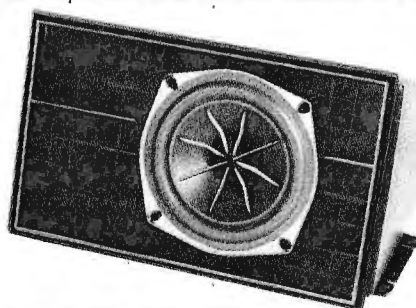


18 A and  $\pm 16$  volts at 2 A), whisper fan, and guides and supports for six cards. The 8080-microprocessor-based CPU board has 8-level vectored priority interrupts, current-status register, and dual-mode realtime clock. The PROM/RAM board contains 1K of RAM and has room for an additional 2K of 1702A type ROM. Included is a 512-byte monitor for use with Tarbell cassette and Altair<sup>TM</sup>, IMSAI, and Polymorphic I/O board and terminal or video board, keyboard, and monitor. \$849 factory assembled, \$619 kit.

CIRCLE NO. 98 ON FREE INFORMATION CARD

### CRAIG CAR STEREO SPEAKER

Craig's Model R780 surface-mount speaker system for cars, part of a line called Trans-Rib<sup>TM</sup>, features a light-mass cone, long-thrust acoustic driver, and special support and sound transmission "ribs." The ribs are supported at the speaker's cone center by the voicecoil and extend outward to distribute all frequencies over the entire surface of the



cone in what Craig claims is precise phase coherence. Additionally, the structural strength afforded by the Trans-Rib elements is said to turn the cone into a rigid true piston for solid bass sounds. Handles up to 50 watts. \$99.95.

CIRCLE NO. 87 ON FREE INFORMATION CARD

### NLS 512-MHZ COUNTER PRESCALER

The Model SC-5 is a compact 512-MHz prescaler designed specifically for the Non-Linear Systems Model FM-7 frequency counter. However, it can be used with any other frequency counter that has a 50-ohm input. Frequency accuracy is stated as being one part per million (1 ppm). Input sensitivity is rated at 30 mV. Supplied with a coaxial input probe that can be used to make direct tests in cir-

cuits or proximity tests from antennas in many circuits, the instrument also comes with an interconnect cable for the Model FM-7 frequency counter. Size is 4"D  $\times$  2.7"W  $\times$  1.9"H (10.2  $\times$  6.9  $\times$  4.8 cm). \$127.00, including rechargeable battery and charger.

CIRCLE NO. 99 ON FREE INFORMATION CARD

### ACE STEREO PREAMPLIFIERS

Two new deluxe stereo preamplifiers are currently being marketed by ACE Audio Co. Designated the Models 3000 and 3100, the preamps feature completely new circuitry that uses both discrete operational amplifiers and integrated circuits and shielded power supplies with dual IC regulators. Both are designed for very low distortion, said to be in the



region of 0.01%. The Model 3000 contains a built-in power supply, while the Model 3100 has its power supply located in an external box. The low-profile preamps also feature aluminum knobs with solid walnut end caps, pushbutton source selector switches, and large knobs for the BALANCE and VOLUME controls. Model 3000, in kit form, \$156; wired, \$250. Model 3100, wired only, \$325.

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### TEST REPORTS:

- Radio Shack STA-2000
- Stereo FM/AM Receiver
- Koss K-145 Stereo Headphones
- Cobra 29XLR 40-Channel AM CB Mobile Transceiver



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**Utility**—Models are available with or without built-in regulated power supplies (fixed or adjustable).

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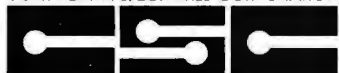
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PB-100	760	10	19.95	Kit — with larger capacity
PB-101	940	10	29.95	8 distribution buses, higher capacity
PB-102	1240	12	39.95	Large capacity, moderate price
PB-103	2250	24	59.95	Even larger capacity: only 2.7¢ per tie-point
PB-104	3060	32	79.95	Largest capacity: lowest price per tie-point
PB-203	2250	24	75.00	Built-in 1%-regulated 5V, 1A low-ripple power supply
PB-203A	2250	24	120.00	As above plus separate ½-amp +15V and -15V internally adjustable regulated power supplies

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# IT TAKES A VERY SPECIAL CASSETTE DECK TO GET SO MUCH BEAUTIFUL MUSIC OUT OF SOMETHING THIS LITTLE.

The recording tape in a cassette is only an eighth of an inch wide.

Crammed into that eighth of an inch may be as many as 64 tracks mixed down to two. A hundred musicians. Countless overdubbings. Not to mention the entire audible frequency range.

Any cassette deck can reproduce part of what's been put down on that eighth of an inch.

But the Pioneer 9191 was designed to reproduce all of it. Superlatively. Without dropouts, unacceptable tape hiss, or noticeable wow and flutter.

Take our tape transport system, for example.

Since the tape in a cassette moves at only 1-7/8 inches per second, even the most minuscule variation in tape speed will make a major variation in sound.

To guard against this, where most



cassette decks give you one motor, the 9191 comes with two. The first is used only for fast forward and rewind, so the second can be designed exclusively to maintain a constant speed for play and record.

All of our tape drive components—the capstan, belt, and flywheel—are finished to incredible tolerances. Which give the 9191 the kind of wow and flutter figures that no deck in our price range can match.

Of course, having a great tape transport system means nothing if you don't have great electronics to back it up.

We do.

The 9191 comes with an advanced three stage direct coupled amplifier that extends high frequency response and minimizes distortion. The built-in Dolby system can reduce tape hiss by as much as 10 decibels in high frequencies.

Our multiplex filter lets you record



FM broadcasts without picking up a lot of unwanted noise, or the multiplex signal every FM stereo station sends out.

Even our ferrite solid tape head offers the best combination of accuracy and long life you can get in a cassette head.

We also include a peak limiter to let you cram as much onto a cassette as possible without distortion. A memory that lets you go back to a favorite spot on the tape automatically. Separate bias and equalization switches for getting the most out of different brands of tape. And electronic solenoid controls for going from play to rewind, or from

rewind to fast forward, without hitting the stop button. And without jamming the tape.

Go slip a cassette into a Pioneer 9191 at your local Pioneer dealer."

You'll find it hard to believe such a little thing could come out sounding so big.

CT-F9191 Specifications:

Frequency Response: Standard, LH tape: 25-16,000 Hz (35-13,000 Hz  $\pm 3$ dB); CrO<sub>2</sub> tape: 20-17,000 Hz (30-14,000 Hz  $\pm 3$ dB)

Signal-to-Noise Ratio: Dolby OFF: More than 52dB; Dolby ON: More than 62 dB (Over 5,000 Hz, Standard and LH tapes/When chromium dioxide tape is used, signal-to-noise ratio is further improved by 4.5dB over 5KHz).

Harmonic Distortion: No more than 1.7% (OdB)

Wow and Flutter: No more than 0.07% (WRMS)

Motor: Electronically-controlled DC motor (built-in generator) x 1; (4.8 cm/s speed drive), DC torque motor x 1; (Fast forward and rewind drive)

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074

**PIONEER**  
High Fidelity Components

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CT-F9191





## New Literature

### SEMICONDUCTOR GUIDE SUPPLEMENT

GTE Sylvania offers a 16-page supplement to its ECG Replacement Catalog. Replacements for more than 3,000 devices used in domestic and foreign equipment are de-

scribed, including both modules and monolithic integrated circuits. All part numbers are listed in alphanumeric order and cross-referenced to equivalent Sylvania replacements. Guide and supplement are available from GTE Sylvania distributors.

### CB ACCESSORIES CATALOG

Siltronix offers a 12-page catalog describing its line of Citizens Band radio accessories. Products include meters, antennas, antenna accessories, speakers, desk mikes and mobile mounting kits. Address: Siltronix, 330 Via El Centro Ave., Oceanside, CA 92054.

### RCA CMOS B SERIES GUIDE

RCA offers a 24-page guide to its B series of

COS/MOS high-voltage integrated circuits, Guide COS-278F. The booklet describes the devices and provides standardized static electrical characteristics information and function classification, selection charts and diagrams. Special information on standard timing circuits is also included. Address: RCA Solid State Division, Box 3200, Somerville, NJ 08876.

### JENSEN HARD-TO-FIND TOOLS

A 136-page catalog from Jensen Tools and Alloys lists over 3,000 hard-to-find tools. Categories covered include micro-tools, test equipment, soldering equipment, screwdrivers, cutters and power tools. A 32-page section features tool kits and cases, and a "Jensen Tool Tips" supplement provides technical data to aid in tool selection. Address: Jensen Tools and Alloys, 4117 North 44th St., Phoenix, AZ 85018.

### TSC COMPUTER SOFTWARE CATALOG

Technical Systems Consultants' catalog of hobbyist computer software includes programs for games as well as practical applications. All are written in assembly language and intended for use with the 6800, 8080 and 6502. Catalogs are 25 cents each. Address: Technical Systems Consultants, Box 2574, W. Lafayette, IN 47906.

### ROYCE CB CATALOG

Royce Electronics offers a 40-page catalog describing its line of 40-channel AM and SSB CB transceivers, antennas and accessories. Items featured include CB mobile and base transceivers with solid-state modular chassis construction, and a new 40-channel in-dash unit with an AM/FM stereo entertainment radio and LED channel readout. Price \$2.00. Address: Royce Electronics Corp., 1746 Levee Rd., North Kansas City, MO 64116.

### AMATEUR RADIO CATALOG

Hamtronics, Inc. offers an expanded 24-page version of its VHF and UHF Communications Modules and Accessories Catalog. Products featured include a vhf/FM receiver kit, test probe kits, audio oscillators and a PA/preamp unit for use with 2-meter rigs. A new line of ac power supplies is described and a section on antennas, cables and connectors is included. Other products described include vhf and uhf receiver and transmitter kits, a full line of preamplifiers and various adaptors. Send a self-addressed-stamped envelope to Hamtronics, Inc., 182 Belmont Rd., Rochester, NY 14612.

### SANKEN AMPLIFIER APPLICATION NOTES

Application notes on the Sanken series S1-1000G hybrid audio power amplifiers are available from Energy Electronic Products. The 4-page flyer provides power derating information, terminal assignments and recommended connections for each amplifier in the series, with a selection of graphs, schematics and outline drawings. A table of technical specifications is also included. Address: Energy Electronic Products Corp., 6060 Manchester Ave., Los Angeles, CA 90045.



When you're miles from help, you need a CB antenna that reaches for miles and miles. It could be your only link to safety. So saving a couple of dollars on a cut-rate brand could cost you.

But the price of an A/S antenna is worth the extra you might pay - just for the peace of mind. Every single A/S antenna is hand-tuned and tested for 23- and 40-channels. That's the kind of care and quality control that makes A/S the choice of

police departments, truckers and safety people everywhere. And that's why A/S has been the leader in antennas for 24 years.

So look for the red and black A/S stripes. You'll be heard when you have to be heard. We'll bet our A/S on it.



M-510 "Big Momma" Heavy Duty Antenna



12435 Euclid Avenue, Cleveland, Ohio 44106 - a member of The Allen Group, Inc.

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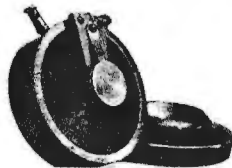
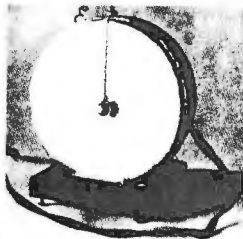
# news HIGHLIGHTS

## Silent Alarm for Automobiles

Said to be the only silent alarm available to prevent motor-vehicle larceny and theft, the "Page Alert System" (Torrance, CA) transmits a coded radio signal from a transmitter in the vehicle to a compact, personal pocket pager in the event theft is attempted. The signal is reported to beep its warning more than 1200 feet, both indoors and outdoors. The person carrying the pager can then make a "crime in progress" call to the police.

## 100 Candles for Mike

The 100th anniversary of the invention of the microphone was marked in 1977. The inventor, Emile Berliner, a 25-year-old immigrant from Germany, created the microphone in an attempt to invent an improved telephone. Introduced on March 4, 1877, the mike made voice and music broadcasting, and electrical recording a possibility. The photo shows the original microphone positioned above the telephone transmitter included in the Berliner Caveat of April 14. The telephone transmitter, forerunner of all talking pieces used in telephones today, was later acquired by the Bell System when a mouthpiece was added. (Photo from Oliver Berliner collection.)



## Voice System Opens Doors

On the basis that no two voices are exactly alike, a new system of "people recognition" has been developed by Air Force Systems Command's Rome Air Development Center (RADC). The computerized "Voice Verification System" will be used to control entry into "secure" or controlled-access areas. Voices are entered into the computer's memory by recording four preselected phrases. Later, to get into a limited-access area, an ID number is entered with a card or a keyboard, telling the computer to go to a particular voice record. The computer asks the person to repeat one of the four phrases. If there is a match, the door opens; if not, the computer asks for another phrase. In operational tests, the system has been more than 99 percent accurate.

## Low-Cost Solar Water-Heating Panels

Designed for the energy-conscious homebuilder, experimenter and hobbyist, a new low-cost solar water-heating panel from Edmund Scientific has a modular design for easy installation. Weighing 11 pounds when empty, 13 when full, the panels, measuring 30" x 30" x 5", can each provide up to 1000 BTU per hour. The panel features a preformed, closed-cell urethane base, a plastic

cover with ultraviolet inhibitors, and a polyurethane solar-energy absorber with integral channels for uniform water flow. Each panel is \$34.95.

## 9111 Dialer OK'd by FCC

The FCC has certified the Conrac 9111 dialer for connection to phone company lines without a coupler. The 9111 dials telephone numbers for police, fire, medical, or other emergencies, and delivers a voice message from a prerecorded tape. A telephone RJ31K jack must be installed by the phone company. When requesting installation of the jack, the installer must give the phone company the FCC number (AE598C-62833-AL-R) and the ringer equivalent—0.0B.

## User Participation

According to RCA Consumer Electronics Division, the \$9 billion consumer electronics industry is slated to move into new product applications that permit the user to be an active participant rather than a passive observer. A wider variety of interactive devices will result as people change the way they buy and use the industry's products and services, according to a company spokesman. Television is expected to be greatly expanded to provide more emphasis on home education and management as new devices become available for use with the TV receiver. Also foreseen is a raft of new electronic products, including an SOS system for fire, smoke, and intrusion devices; widespread use of the picture telephone; home TV systems with built-in video game capability and video record/playback; wristwatches that electronically read out the time, date, temperature, and blood pressure; and a wrist radio using microelectronics and satellite techniques which could be used for electronic voting, census taking, civil defense, medical monitoring, and instant communications with police and other security agencies.

## Japanese To Share FCC Testing

Japan laboratories will be doing a share of the testing of new CB radios manufactured in that country. Under a recent agreement with the Federal Communications Commission, Japanese manufacturers will submit model test data and samples to the Ministry of International Trade and Industry (MITI), which will forward results and samples to an independent Japan testing laboratory. These results will then be sent to the FCC for the final decision on type acceptance. The new program is not mandatory; Japanese manufacturers with contracts with U.S. distributors have the option of submitting models to the FCC lab. It is hoped that the new program will lighten the FCC workload, enabling it to focus on other areas such as off-the-shelf testing of CB radios and video games. Of the projected 10 million CB radios expected to be sold in the U.S. this year, 90 percent will have been manufactured in the Far East.



NRI BRINGS "POWER-ON"  
TRAINING TO YOUR HOME...  
FOR QUICKER, EASIER  
LEARNING AND  
FASTER EARNING

# NRI FIRSTS

**First** and only school with designed-for-learning Quadraphonic Audio Center with four SP14 speaker systems. This solid state SQ™ system is designed so that you perform meaningful experiments at every stage of assembly . . . for thorough training in audio technology.



™Trademark of CBS, Inc.

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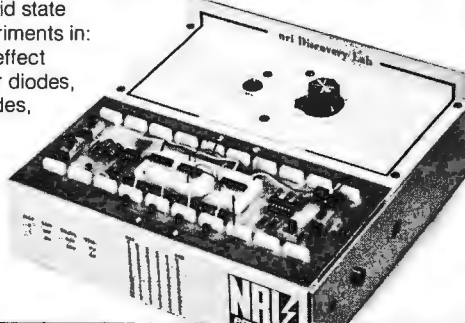
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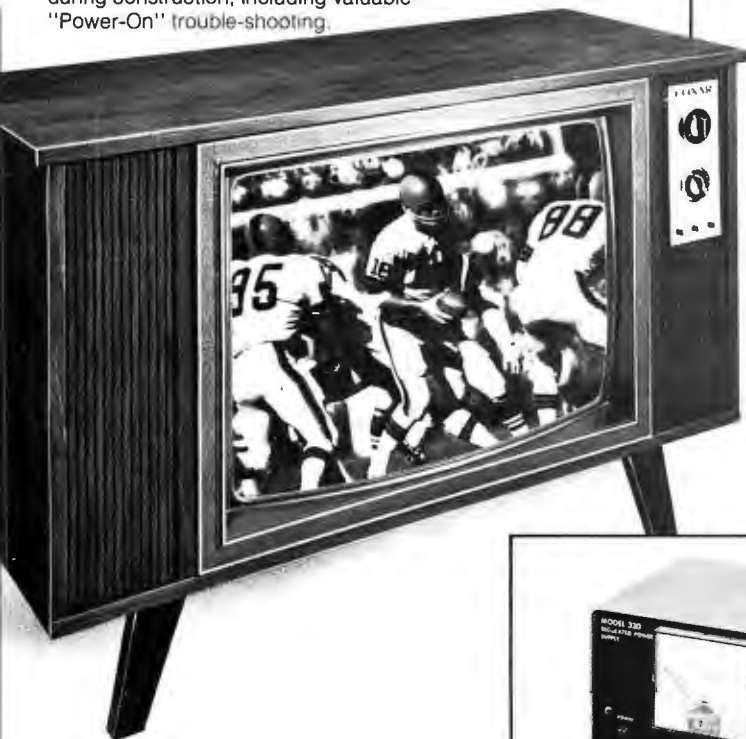
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# Stereo Scene

By Ralph Hodges

## EXPANSIVELY SPEAKING

**A**N EXPANDER, like a compressor, is an amplifier whose gain changes with a change in input voltage. High voltage means high gain; low voltage, low (even negative) gain; and medium voltage, something like unity gain. Compressors (compressors used in tandem with complementary expanders) are the bases for today's most popular noise-reduction systems. But expanders used by themselves also present appealing possibilities, or so say several consumer manufacturers. To wit: the signal coming out of them has a greater dynamic range than the signal that went in. Therefore, if the everyday recordings you play, have restricted dynamics for one reason or another, an expander can enhance their sound.

This is a possibility, but of the consumer-type expanders I've heard at any length, virtually all of them have not been able to avoid being "caught out" on some piece of program material or other. Being "caught out" means sounding somehow unnatural, calling attention to the processing behind the scenes.

As a first example, there is the "zoom lens" effect. This is prone to occur when the instrumental backup on a recording hits a sudden, mighty crash, calling upon the expander for a big boost in gain. This boost cannot be limited to only those instruments going "crash," however. *Everything* gets boosted, including the lead vocalist(s), who may thereupon seem to lurch forward into the room at you—an unsettling experience under the best of circumstances and a positive panic if you happen to be listening to "Kiss."

A related phenomenon is the "HOP-pitty-HOP-pitty" that takes place when some hearty, repetitive thud from the rhythm section modulates all the rest of the instruments in loudness according to its own beat.

Another anomaly is "ambiance truncation." As you're no doubt aware, the usual expander expands both upward and downward, making loud sounds

louder and soft sounds softer. To an expander, the decay of reverberation following a big orchestral moment looks like a decrescendo, and its tendency is to make that decrescendo more abrupt and extreme, thereby abbreviating the pleasant afterglow resulting from natural reverberation.

A semi-satisfactory cure for this, and for the "HOP-pitties," consists of extending the decay time of the expander, so that the device remains in a "boost" condition (once it has been put there by the program material) for an artificially long time. This should not be overdone, however. There are antiphonal moments in symphonic music when a huge blast from the full orchestra is quickly "answered" by, for example, the delicate tinkle of a triangle—which won't be so delicate if the expander stands ready to slap a big boost on it. And there are always a few records in which the first-desk trumpet, having blown himself purple in the face for a stunning climax, cannot manage to suppress a cough as the last note dies away. A strategically located blemish on the record surface will have a similarly shattering effect when the expander boosts it up out of all normal proportions.

These problems, and others, are no mystery to expander manufacturers, who usually juggle attack and decay characteristics for the best possible effect with the greatest number of recordings. Even so, the tasteful user often finds he can get away with only mild degrees of expansion (low expansion coefficients), and he may get to the point where he finds it necessary to readjust the device for every record. At least one expander comes into operation only at the extremes of loud and soft, which seems to make adjustment less critical, but which also results in a rather subtle effect—or, indeed, no effect at all—much of the time.

**A Multi-Band Expander.** The compressor noise-reduction systems share a

few (but by no means all) of these unwelcome side effects with straightforward expanders. One reasonably effective way around them has been to operate the compander in separate, independently processed frequency bands, à la the Dolby A-type system. In particular, this scheme is accepted as being an effective remedy for so-called noise "pumping" or "breathing." Such "pumping" takes place when an expander boosts both a solo string bass on a recording *and* the tape or disc noise—inevitable if the expander works in only one full-range frequency band. But if there are separate, strategically chosen frequency bands, the bass can be confined to entirely separate low-frequency circuits, and be processed without any great effect on higher frequencies.

In straight expander applications, multi-band operation has other theoretical advantages. The "zoom lens" effect may be avoidable if the instruments prompting the expansion boost lie outside the frequency band controlling the vocalist. Low-frequency bands can be designed with a long decay time, high-frequency bands with a rapid one, which might conceivably improve the subjective handling of reverberation.

The dbx Model 3BX is a multi-band expander—the first I know of to become available to consumers for this application. The configuration chosen is three bands per channel. (It is a stereo device.) I have been giving a 3BX the works now for several weeks, and although prior experience has made me less than a fan of this kind of signal processing (a view not necessarily shared by others, admittedly), I think the 3BX shows that real progress is possible. The expected side effects and anomalies seem to be avoided much more consistently than I'd have believed possible with this (after all) rather simple elaboration of expansion techniques. Even when they could be detected, they never absolutely "rang false." Consequently, for much recorded material, I could use the full degree of expansion available (1.5 to 1) without distress (although for recordings already exhibiting satisfactory dynamics this is probably too much). Gratifyingly, the 3BX does not "sound" like an expander to me. For much of the time it *does* sound like a very effective noise-reduction system as (for quieter passages) the higher-frequency bands drop to very low gain.

The unit's front panel has three rows of LED's (ten per row) corresponding to its three bands, plus a calibrated expansion-coefficient control and another slide



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The dbx 3BX, showing the three rows of LED indicators.

pot to set overall operating level. This last is adjusted so the recording's mean levels light the LED's near the center of their respective rows. When this is done, the mean levels will undergo no expansion; higher levels will be expanded upward (boosted) and lower levels downward. The LED's wink up and down to show the degree as well as the direction of the expansion.

The dbx manual does not specify the bands of operation or the attack and decay characteristics chosen for each (it does suggest that they are appropriately different, however). I tried to get some sense of these time constants by watching the LED's, but failed.

In my view, the 3BX had one persistent fault (an effect that must be evaluated by each individual user): it functioned as a sibilance enhancer on many vocal recordings. Sibilance can be very intense on both tape and disc recordings, sometimes exceeding the level of any other material at isolated moments. Many phono cartridges have trouble with it, and may mistrace or mistrack in such a way as to accentuate it. On numerous occasions, I saw the LED's for the 3BX's high-frequency band really take off in the presence of loud "ssss" sounds, while the rest of the display remained comparatively sedate. Usually this was accompanied by a really piercing "spit" of sibilance, although the effect was notably cleaner and hence much less annoying on some recordings (the generally good ones) than on others. Discrete record noises (scratches, etc.) were enhanced in the same way. I wonder if the high-frequency band's operation could be modified or disabled (by a switch) to eliminate this minor annoyance when desired without severely compromising the processor's other good characteristics.

**Phase Coherency.** A few weeks ago the first "phase-coherent" speaker system I've managed to lay hands on appeared at the doorstep. A phase-coherent loudspeaker reputedly has the ability of regulating phase and arrival-time-at-listener characteristics between drivers to the point where complex waveforms actually arrive at the listener's ear—or, in this context, at a measuring micro-



The DM6 does not produce a very

More important is how it sounds. In direct comparison with the totally non-phased system (which is however regarded as an excellent speaker) other listeners and I have heard no differences that we aren't inclined to attribute to very easily measurable frequency-response factors. We have used recorded material that involved both the most complex and the simplest arrays of microphones and associated equipment, including tapes we made. We also used spoken voice miked live from an adjoining room. At times there was an impression of greater unspecific space or "air" around the nonphased multi-directional pair, but otherwise the stereo imaging (in terms of localization and depth) was excellent and virtually identical from both systems. This came as a surprise; all of us were expecting some capability in the phase-coherent pair for added sharpness of localization or more precise depth information. But so far, any differences, qualitative or quantitative, have eluded us. We'll see what further developments bring. ◇

**\*Patent Pending**

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## Audio Reports



### **SPEAKER SYSTEM MEASUREMENTS— IS PHASE RESPONSE IMPORTANT?**

**F**or many years, attempts have been made to identify the parameters that determine the sound of a speaker system. Some parameters, such as frequency response, appear to be obvious, but if given a little thought, they are less clear than those for other components in a sound system. Unlike a tuner or amplifier, for example, a speaker system does not have definite input and output ports. The input is simple enough—a pair of terminals that present a rather complex impedance load to the signal source. Since amplifiers are constant-voltage sources, the impedance of a speaker system can be assigned a secondary place in the hierarchy of the parameters that affect the sound.

The "output" of a speaker system is even more complex. There is no single "output" from a speaker system that uniquely determines its sound. This is perhaps the major problem for anyone who wishes to measure speaker system performance objectively and meaningfully. Some people who test speaker systems consider the acoustic pressure generated to be the system's output. This raises the question about how this pressure is to be measured. In general, the pressure measurement is an unpredictable function of the distance and direction between the speaker system and the measuring microphone. Furthermore, in any room that does not absorb all the acoustic energy impinging on its boundaries (this is any room except a properly designed and constructed anechoic chamber), some energy will reach the microphone by reflection. The reflected energy cancels or adds to the direct-energy component and causes appreciable response fluctuations as the frequency is changed. These are independent of the response characteristics of the speaker itself.

Anechoic measurements can produce impressive curves that tell us little about how the speaker system actually sounds. In the real world, we hear a composite of the direct-energy output from a speaker system and a multitude of reflections from the room surfaces. This sound is closely related to the total acoustical output power delivered by the speaker system to the volume of air that loads its cones. The power output is an integration of the square of the sound pressure level (SPL) over the spherical boundary, or fraction thereof, into which the speaker system faces. It can be measured in a cumbersome point-by-point manner and processed by a computer. Fortunately, it is also possible to measure the total output power of a speak-

er system directly in a reverberant chamber. This is a room with hard, nonparallel surfaces that absorb almost no sound energy.

The reverberant response of a speaker system is close to being the analog of its perceived (subjective) frequency response. It is not exact, but almost nothing in the entire process of sound reproduction is exact. Since a reverberant chamber is at least as large and expensive as an anechoic chamber, it is a tool of a well-equipped speaker design laboratory and is unlikely to be included in the facilities of even an up-to-date private laboratory. However, even a normally furnished listening room has many of the properties of a reverberant chamber.

If one remains beyond a certain distance from the speaker system, the SPL varies little throughout a large portion of the room. When this condition is satisfied, one is said to be in the "reverberant field" of the room. Apart from any theoretical compromises involved in measuring speaker system response in the reverberant field of a normal room, the room has the virtue of being a realistic environment for speaker system testing. It is in this environment that the speaker system will be used and listened to, and it makes sense to evaluate it under these conditions. In our room, the measured response over most of the frequency range from several hundred hertz to 15,000 Hz varies by only a couple of decibels with large changes in the position of the microphone or speaker with the two at least 10 ft (3 m) apart.

In either a reverberant or a quasi-reverberant measurement, it is usually impractical to go below about 500 Hz because of standing waves in the room. (Anechoic chambers also have low-frequency limitations, unless they are prohibitively large.) Thus, it is necessary to measure the woofer's response with a microphone placed as close as possible to the cone. This effectively removes the room from the measurement environment. Splicing this curve to the one obtained in the reverberant field, we obtain a composite curve that, although not completely a property of the speaker, is nevertheless a good indicator of how it will perform in a real listening room. The larger trends in energy response versus frequency can be seen easily and usually correlate well with listening tests.

There is much more to the process, but the preceding is a simplified description of the "frequency response" measurements made by Hirsch-Houck Laboratories on speaker systems. The result is not the fre-





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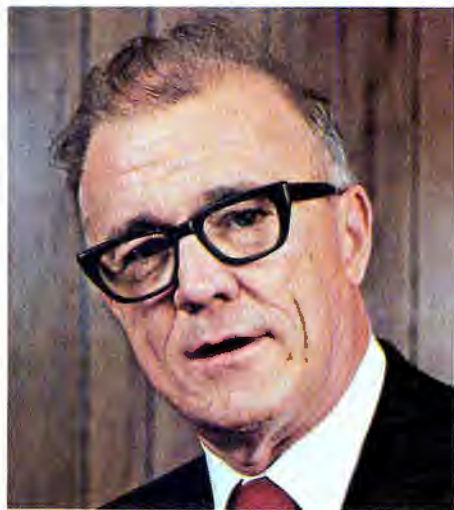
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quency response; it could more accurately be described as a frequency response, one of an infinite number of possible responses.

Now that we have dealt with frequency response, what about *phase response*? To preserve the shape of a complex waveform, all frequency components must be maintained in their correct amplitude and phase relationships. Reversing the phase of one harmonic in a square-wave signal, for example, can completely change the shape of the "square" wave, even though a spectrum analysis of the signal will reveal no change. If preservation of the waveform is important to accurate sound reproduction, a linear phase speaker system would appear to be a necessity. The phase shift of the output of such a speaker system, relative to the input signal, would increase in proportion to frequency so that all signals within the audio range would be propagated without any differential time delay. A square-wave input signal would be recoverable as an acoustic square wave, subject only to the natural bandwidth limitations of a speaker system.

The need for, or the desirability of, a linear phase characteristic has a certain logical appeal. It is difficult to imagine that phase shifts that can totally alter the shape of a signal waveform cannot be heard. Nevertheless, many experimenters over the years have come to this conclusion. On the other hand, it is possible to prove—or disprove—just about anything by establishing the appropriate experimental conditions. Recently, there have been some indications that extremely small phase shifts can be heard under certain narrowly defined circumstances. We prefer to remain neutral about this at this time, but it might be instructive to relate a personal experience we had recently when we visited the Osaka headquarters of Matsushita Electric, manufacturers of the Technics by Panasonic high-fidelity product line.

Technics has made a determined effort to remove speaker system phase shifts from the high-fidelity reproduction equation. At the company's speaker laboratory, a linear phase speaker system, similar to the Model SB-6000A, reviewed in this issue, was placed

in a large anechoic chamber and driven by a square-wave signal. The output of a microphone placed several feet in front of the speaker system, was viewed on an oscilloscope, where it could be seen to be an excellent square wave. This was convincing evidence that Technics had achieved a linear phase shift, or negligible time delay distortion. During the demonstration, the tweeter was physically moved back and forth as we listened inside the chamber to the square-wave output signal. As expected, the waveform on the oscilloscope underwent rather drastic changes, but we could hear no significant differences in the character of the sound. The key word is *significant*, since any changes that took place were of the same magnitude that resulted from a slight head movement or a shift of a few inches in listening position.

Our tests of the Technics Model SB-6000A, using the methods described and a number of others, revealed that it is a very fine speaker system in every respect. The obvious question is: does the phase linearity of the speaker system account for its excellence, at least in part? Or is it simply a good speaker system, for reasons not directly related to its phase characteristics? Well, we have tested and "lived with" a couple of other "linear phase" speaker systems that use somewhat different design principles. In side-by-side comparisons, the Model SB-6000A, in our judgment, was far superior to the others. On the other hand, we have conventionally designed speaker systems that make no claim to phase linearity and are roughly equivalent in accuracy to the Model SB-6000A in the same comparison. They do not sound identical to the Model SB-6000A (no two speaker systems sound alike) but they are of comparable quality—*without* phase linearity—though those A-B'd were costlier.

Maybe a good speaker system with phase linearity is better than a good speaker system without it, but returns in this controversy are not yet counted. As always, we recommend that the consumer be more concerned with how *well* a product performs, rather than with its special or unique design principles. After all, we do not listen to principles.



### TECHNICS MODEL SB-6000A LINEAR PHASE SPEAKER SYSTEM

*Innovative design provides top performance and high efficiency.*



years ago, it was principally to point out how inferior available speaker system designs were in this respect. Now we are beginning to see speaker systems designed to dramatically reduce unwanted phase shifts that can seriously distort waveforms. A fine example of the

When speaker phase response began to be mentioned in the technical press a few

new linear phase design is the Technics by Panasonic Model SB-6000A.

The Model SB-6000A is a two-way system that contains a 12" (30-cm) woofer and a 1¼" (3.2-cm) dome tweeter. The crossover frequency is at 1800 Hz. The enclosure features a bass-reflex design, with a ducted port near the top of the cabinet. The relatively high-efficiency, 6-ohm speaker system is rated to produce a 91-dB SPL at a 1-meter distance with 1 watt of driving power.



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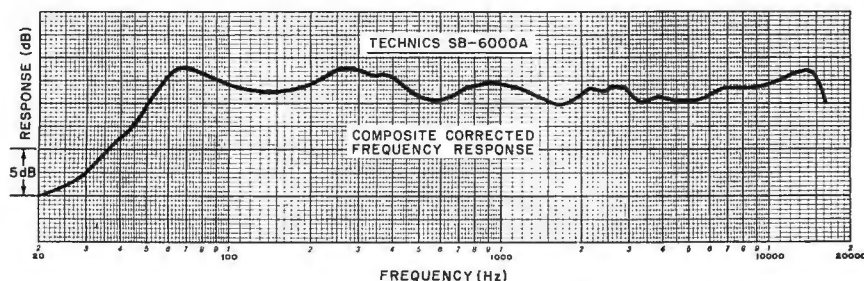
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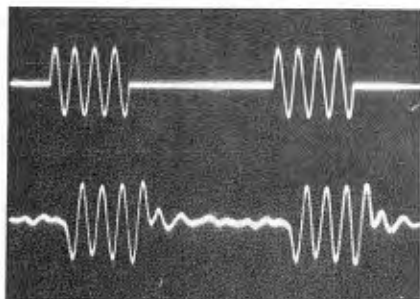
*Composite corrected frequency response of Technics SB-6000A speaker.*

Additionally, it is rated to handle up to 100 watts of program power without risking voice-coil burnout or mechanical damage to the driver. (A graph that accompanies the installation instructions illustrates the maximum permissible power as a function of frequency and duty cycle.) The frequency response of the system is stated as 39 to 22,000 Hz, based on the output at the limit frequencies being 10 dB below the average mid-range level.

The speaker system measures  $33\frac{1}{4}"H \times 16\frac{3}{4}"W \times 13\frac{3}{8}"D$  (84.6  $\times$  42.5  $\times$  34 cm) and weighs about 55 lb (25 kg). The national advertised value of the system is \$299.95.

**General Description.** Technics has designed the speaker system so that the woofer and tweeter are as close together as possible. To accomplish this, the woofer is mounted near the top of the ported enclosure, 21" (53.3 cm) above floor level, and the tweeter employs a square magnet assembly. The tweeter is mounted outside the main enclosure that houses the woofer, directly above the woofer and set back from the front of the main enclosure. Also on top of the enclosure are the speaker-hookup terminals, a continuously variable tweeter control, and a graph that shows the effect of the level control on the system's frequency response. An easily removable black fabric grille and top cover hide the drivers from view.

All exterior surfaces of the speaker system are finished in flat black, except for two vertical metal rods at the front corners of the main cabinet.



*Tone-burst response at 1000 Hz.*

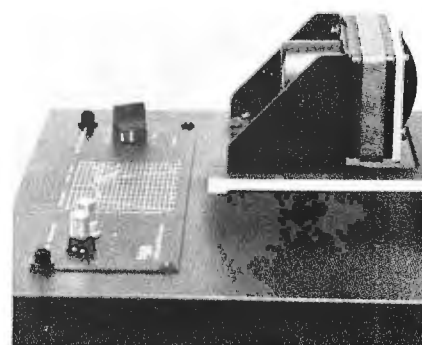
The linear phase response was achieved by combining a specially designed crossover network with drivers that have a linear phase response within their individual operating frequency ranges and by locating the tweeter behind the woofer's front surface where the path lengths of their respective outputs are identical.

**Laboratory Measurements.** Since we did not have the facilities to check the claimed linear phase response of the speaker system, we followed our standard loudspeaker test procedure. The frequency response, measured in a normally "live" room, was remarkably free from the peaks and dips typically found when measuring speaker systems under these conditions. From 1000 Hz upward, virtually no smoothing was required to derive our averaged response curve from individual measurements of the two speaker systems in their normal stereo locations, with a single microphone position near the rear of the room.

The woofer response was measured with a close microphone spacing to eliminate room effects, and was combined with the response measured at the bass reflex port to obtain the system response below a few hundred hertz. Splicing this to our high-frequency curve, we came up with an impressively flat composite frequency response that was within  $\pm 2$  dB from 50 to 16,000 Hz (the effective upper limit of our microphone's calibration). Over much of this range, the response was at least as flat as the resolution of our measurement system, or within  $\pm 1$  dB from 450 to 10,000 Hz. There was a slight rise in output, of 2 to 3 dB, in the 200-to-400-Hz octave and a bass resonance rise of about the same amplitude at about 70 Hz. The bass output was 10 dB below the average midrange level at 27 Hz. (This would be strongly affected by room dimensions and speaker placement in any specific installation.)

These measurements were made with the tweeter level control set to max-

imum, which was the setting for a recommended "flat" response. When we turned down the tweeter level control the output was cut above 1700 Hz with no effect whatever at lower frequencies. This contrasts sharply with many speaker-balance adjustment schemes in which system response is affected at frequencies well removed from the nominal crossover points. The bass distortion was measured with close microphone spacing at frequencies of 100 Hz and below. Tests were made with constant drive levels corresponding to 1 watt and 10 watts input and with the drive adjusted to maintain a 90-dB SPL at a distance of 1 meter from the speaker. Again, the speaker system was somewhat unusual in that the shape of its distortion curve and its "break" point at about 35 Hz did not change significantly with power. Of course, the actual distortion at each test frequency was higher with 10 watts input than with 1 watt. The 90-dB SPL curve fell approximately midway between the two curves. The actual distortion at 1 watt was less than 1% down to 45 Hz and rose to 4% at 30 Hz and 16% at 25 Hz. These can be considered exceptionally low distortion figures for any speaker system.

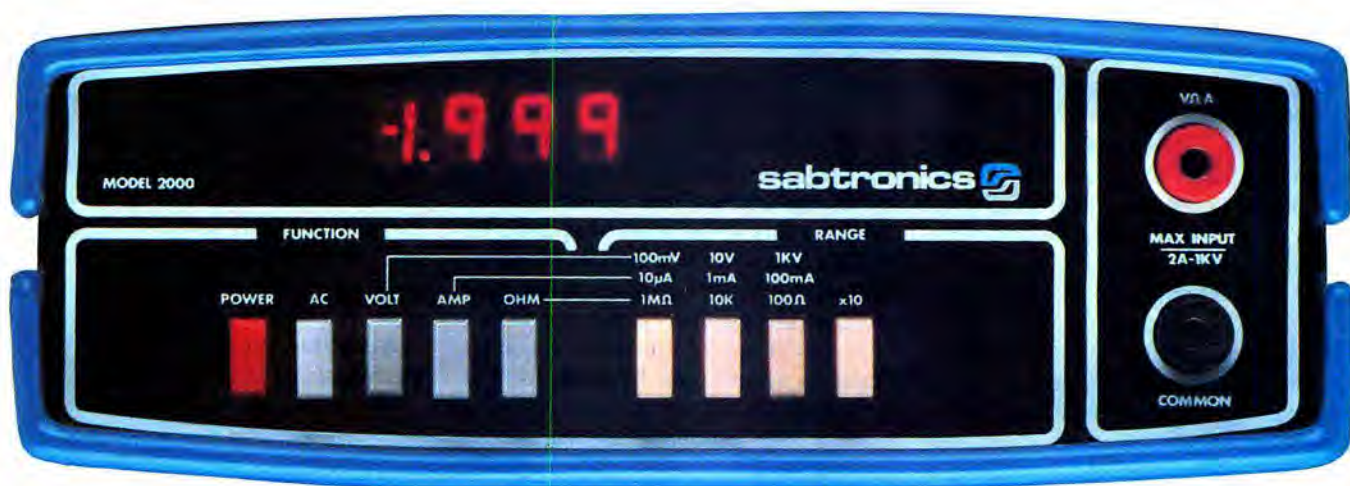


*Top of system showing response curves, terminals, and controls.*

Although we could not check phase linearity (for instance, by square-wave measurements) in a "live" environment, we found that the tone-burst response of the system was considerably better than average at all frequencies. In fact, it changed little with frequency. The 1000-Hz burst response photo is typical of what we observed. The system impedance reached a minimum of 5 ohms between 1000 and 6000 Hz and a maximum of 50 ohms at the 58-Hz bass resonance. The speaker, as claimed, was quite efficient, and delivered a 91.5 dB SPL at 1 meter when driven with 1 watt random noise in the octave centered at 1000 Hz.



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**User Comment.** It was obvious from our measurements that the Technics Model SB-6000A must rank as a fine speaker system, excelling in just about every characteristic for which we were able to test. However, the proof of a system's performance is in the listening, and we performed the simulated "live-versus-recorded" test with considerable interest.

There were no surprises here. Side-by-side with our "live" music source, a loudspeaker reproducing wide-range music program material, the Model SB-6000A matched the "live" sound (recorded anechoically on the second track of the 15-ips half-track tape carrying the original program) with above-average accuracy. The midrange and highs were virtually perfect, with the latter being dispersed more effectively than by most other dome-type radiators we have heard. In the lower midrange, there was

a slight "warmth" which we attribute to the 300-Hz rise in the response curve.

Playing other types of program material, the system displayed the same qualities, with the addition of a very potent bass output. (The live-versus-recorded test is limited to frequencies above 200 Hz.) We located the speaker system well away from the room corners, but within 6" (15.2 cm) of a wall, with good sound balance.

We are in no position to judge how much of the system's excellent sound quality comes from its linear phase characteristics and how much from its simply being a very good speaker system. Of course, this is not an important consideration in the evaluation of a speaker system. What is important is the evident fact that this is one of the better sounding speaker systems we have heard in a long time.

The high efficiency of the Model

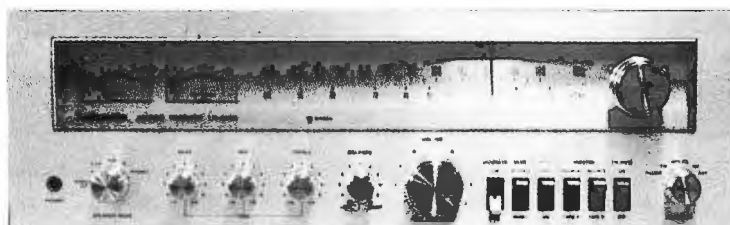
SB-6000A is another "plus," since it can deliver an impressive amount of clean, undistorted sound when driven by a modestly powered amplifier. In spite of this, it was able to absorb most of the power available from a 200-watt/channel amplifier without audible distress or damage to the drivers.

Styling, of course, is a purely subjective matter. The appearance of the Technics SB-6000A is not conventional, and no doubt it would be aesthetically incompatible with some home decor. But we found its external design to be both attractive and functional. It would appear that Technics has laid to rest the notion that Japanese speaker systems do not match the taste of the American audiophile. You just have to listen to the Model SB-6000A speaker system to shatter this mistaken belief.

CIRCLE NO. 101 ON FREE INFORMATION CARD

## LAFAYETTE MODEL LR-3030 AM/STEREO FM RECEIVER

*Delivers 30 watts/channel at moderate price.*



Lafayette Radio Electronics' Model LR-3030 AM/stereo FM receiver is representa-

tive in appearance of the company's redesigned 1977 line. It is rated to deliver 30 watts/channel into 8-ohm loads at 1000 Hz with no more than 0.5% total harmonic distortion (THD).

The receiver comes with a metal dust cover and wood-finished side panels. It measures 19 3/4"W x 14"D x 6 1/2"H (50.2 x 35.6 x 16.5 cm) and weighs 24 lb (11 kg). Price is \$299.95.

**General Description.** Instead of the usual "blackout" dial window, the tuning scales of this receiver are always visible through a clear window. To the left of the scales are two large illuminated meters that indicate signal strength on AM and FM and center-channel tuning on FM only. Below the dial scales is a red LED that comes on when a stereo FM broadcast is being received.

Across the bottom of the front panel, from left to right, are a headphone jack, combined speaker selector and power switch, tone controls (bass, midrange, treble), and balance control. The three tone controls are each detented at 11 positions, while the balance control is detented at its center position. The speaker selector switch can be used to connect either, both, or neither of two pairs of speaker systems to the outputs of the power stages. (If the B pair of speaker systems is located toward the rear of the listening room, a 4 CHANNEL position on the speaker selector switch allows them to be driven with difference channel material to simulate 4-channel sound via the ambience-recovery principle.)

The large VOLUME control knob can be set to any one of 40 detented positions. The input selector, located at the far right of the front panel, has positions for PHONO, AUX, FM, and FM with an MPX FILTER that partially blends the higher frequencies to reduce noise on weak

stereo FM signals. Six lever switches control the loudness compensation, stereo/mono mode selection, high-cut filter in/out, FM muting, and tape monitoring (the last for two decks).

On the rear apron of the receiver are insulated spring clips for speaker system hookups and binding-post terminals for 300- and 75-ohm FM antennas and an AM wire antenna. There is also a pivoted AM ferrite-rod antenna. A switch is provided for setting the sensitivity of the phono inputs for high- and low-output magnetic cartridges. Each speaker output is separately fused, and there is a single unswitched ac outlet.

The receiver employs 11 IC's. The power output stages are hybrid IC modules, and the phono preamplifiers use op-amps. The tuner section contains an IC that functions as an FM i-f amplifier, limiter, and detector, another IC for the multiplex demodulator, and a third IC for the AM tuner section. In essence, discrete solid-state components are used only for the FM front end, audio tone control amplifier, and power supply regulator sections.

**Laboratory Measurements.** To bring the receiver to operating temperature, we ran it for an hour at one-third power and five minutes at full power. At this point, the audio amplifier clipped just short of 40 watts/channel at 1000 Hz into 8-ohm loads. The power into 4- and 16-ohm loads was 48 and 26 watts/channel, respectively. The con-



# /ability.

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choice of four different memory boards and many others.

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8K ALTAIR BASIC has facilities for variable length strings with LEFT\$, RIGHT\$, and MID\$ functions, a concatenation operator, and VAL AND STR\$ functions to convert between strings and numbers.

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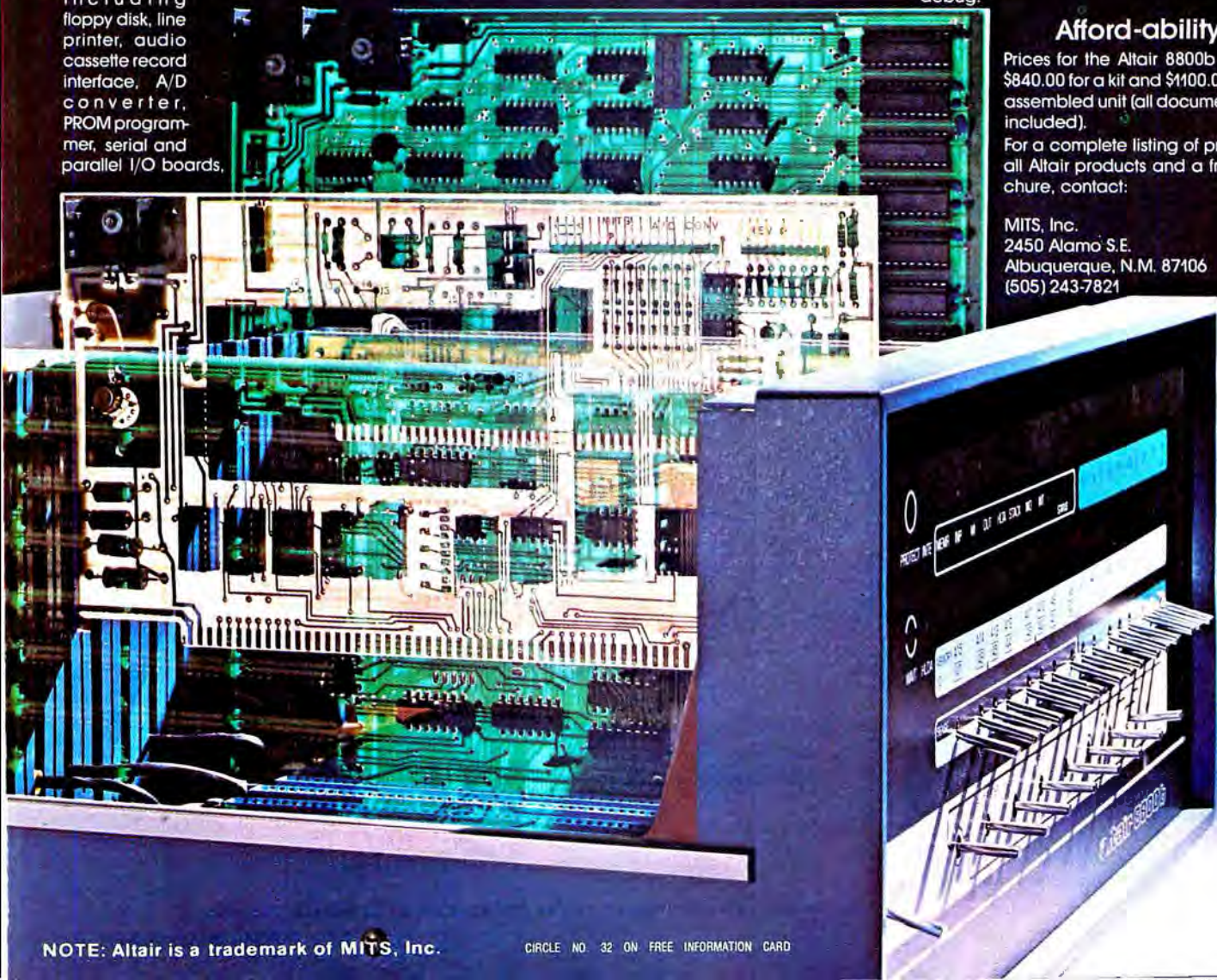
Package II, an assembly language development system for the Altair 8800b, includes system monitor, text editor, assembler and debug.

### Afford-ability:

Prices for the Altair 8800b start at \$840.00 for a kit and \$1100.00 for an assembled unit (all documentation included).

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Inside of receiver showing hybrid IC's for output stages.

servatism of Lafayette's ratings can be appreciated from the fact that the 1000-Hz THD was less than 0.01% between 0.1 and 1 watt output and a smooth increase to only 0.027% at 35 watts output. At the clipping point of 40 watts output, the THD measured only 0.1%.

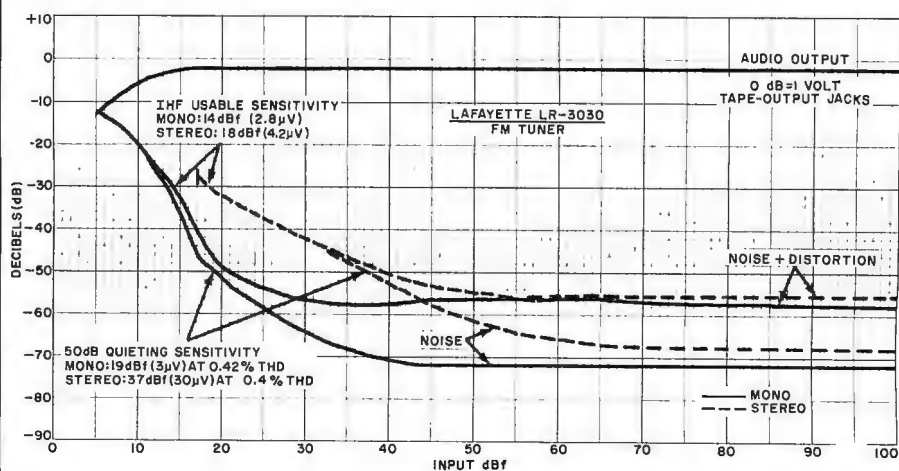
The IM distortion measured between 0.023% and 0.073% from 0.1 to 35 watts and 0.1% at 40 watts. At the rated 30 watt output, the distortion was about 0.02% from 20 to 20,000 Hz. It increased to about 0.06% in the octave between 10,000 and 20,000 Hz. At half power, it was about the same, and at one-tenth power, the only difference was a slight increase in distortion at low frequencies (to 0.05% at 20 Hz).

To produce a reference 10-watt output, the AUX input required an 80-mV signal. The S/N ratio was very good

here, measuring 82 dB. Through the PHONO inputs, the sensitivity was 1.9 or 3.8 mV, depending on the setting of the rear-panel sensitivity switch. The S/N here was 72.5 dB. The phono overload capability was excellent, especially for a receiver in the Model LR-3030's price range. Clipping occurred at 265 and 530 mV with the sensitivity switch set to its alternate positions.

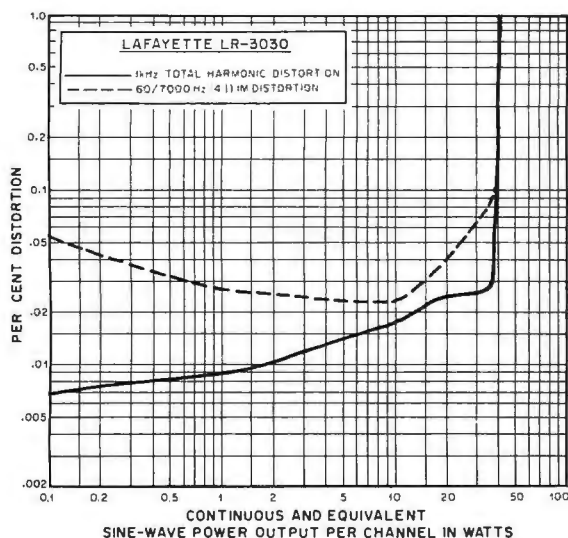
The bass tone control's turnover frequency slid between 100 and 300 Hz as the control was advanced. The treble response curves were hinged at about 3000 Hz. The midrange control affected a broad range of frequencies, from approximately 300 to 4000 Hz and had a maximum range of  $\pm 6$  dB.

The loudness compensation boosted both low and high frequencies relative to the midrange as the volume was reduced. The high-cut filter had a 6-dB/



Noise and sensitivity curves for FM section of Lafayette receiver.





*Total harmonic distortion and 60/7000-Hz distortion.*

octave slope, with the  $-3$ -dB response point at 4000 Hz. Its effect on the frequency response was little different from that of the treble tone control. The RIAA phono equalization was very accurate, varying less than  $\pm 0.5$  dB from 20 to 20,000 Hz. Apparently because of the op amp configuration of the phono preamplifiers, which completely isolates the signal input circuits from the feedback equalization components, the phono response was totally unaffected by cartridge inductance.

The FM tuner section had an IHF sensitivity of 14 dBf (2.8  $\mu$ V) in mono and 18 dBf (4.2  $\mu$ V) stereo. The 50-dB quieting sensitivity was 19 dBf (5  $\mu$ V) in mono, with 0.42% distortion. In stereo, it was 37 dBf (38  $\mu$ V), with the same distortion level. The ultimate quieting (S/N) was 72 dB in mono and 68 dB in stereo. FM distortion was very low, measuring 0.15% in mono and 0.17% in stereo. The stereo distortion with L-R modulation was 0.85% at 100 Hz, 0.32% at 1000 Hz, and 0.14% at 6000 Hz.

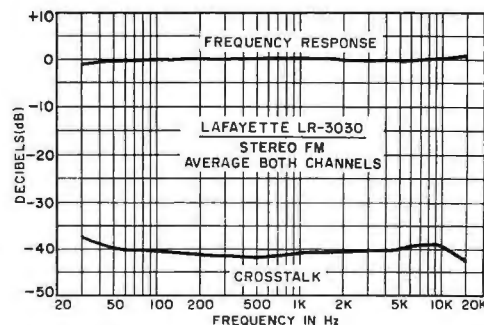
Capture ratio was an excellent 1.25 dB at 65 dBf (1000  $\mu$ V) and 1.1 dB at 45 dBf (100  $\mu$ V). The AM rejection at these levels was 59 dB and 62 dB, respectively. Image rejection at 98 MHz was 55 dB. Alternate-channel selectivity was 64.5 dB, and adjacent-channel selectivity was 7 dB. The muting and stereo switching thresholds were identical at 19 dBf (5  $\mu$ V). Hum level was  $-67$  dB.

The FM frequency response was almost perfectly flat, within  $\pm 0.5$  dB from 50 to 15,000 Hz. It was down only 1 dB at 30 Hz when measured at the tape recording outputs. In spite of the complete absence of any rolloff at 15,000 Hz (the usual result of the low-pass filter used to cut out pilot carrier leakage), the 19-kHz component in the audio output was an

insignificant  $-68$  dB. Stereo channel separation was unusually uniform as well as very high, measuring from 38 to 42 dB over the full 30-to-15,000-Hz range. The AM frequency response was quite restricted, being down 6 dB at 50 and 3000 Hz.

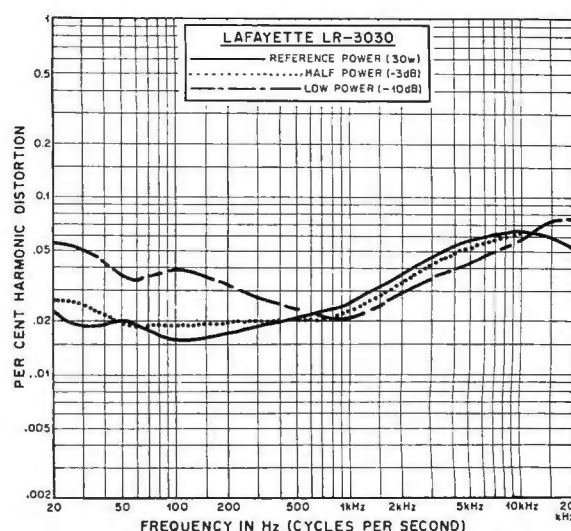
**User Comment.** In most cases, our measurements revealed that the receiver met or surpassed its ratings, usually by a comfortable margin. One of the few exceptions was the FM sensitivity, rated at 11.2 dBf, or 2  $\mu$ V. The difference between our measurement and the rated value is insignificant, partially explainable by differences in test equipment

*Frequency response and crosstalk averaged for both channels in stereo FM.*



and measurement conditions. In our view, the many other respects in which the receiver excelled more than made up for this trivial discrepancy.

Obviously, this receiver has all the qualities necessary for true high-fidelity performance. In addition, and every bit



*Harmonic distortion at three power levels.*

as important, it has the smooth operating "feel" that we associate with advanced (and usually expensive) components. Every control works smoothly and with a positive action. The FM muting system is one of the best we have used. (There were no noises whatsoever when tuning; we merely heard the programs coming on and going off smoothly.) The FM dial calibration was very accurate, with the linear dial calibrations spaced at 1-MHz intervals.

We did not use the 4 CHANNEL operating mode, but past experience with this type of ambience-recovery system indicates that it is the least expensive method of enhancing stereo sound quality.

Tape recording enthusiasts will appreciate that the monitoring switches can be set to dub from deck A to deck B, though not in the opposite direction.

In all, the LR-3030 is unequivocally a fine receiver for the money.



# CT-64 TERMINAL SYSTEM



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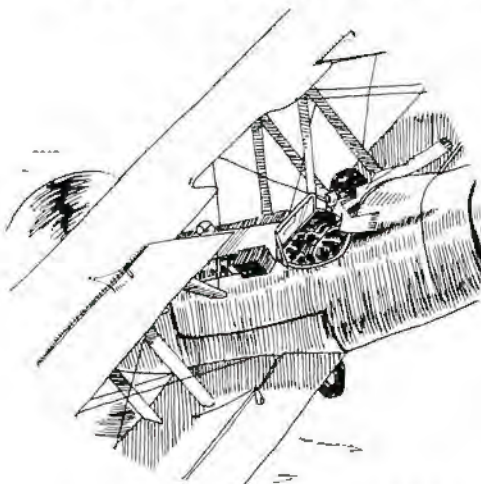
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## TEST YOUR ESP



## BATTLE THE DIVE BOMBER



## BIORHYTHM FORECAST



# HOW TO PROGRAM CALCULATORS FOR FUN AND GAMES

**W**ITH THE growing popularity of hand-held programmable calculators, hundreds of users are programming them to do things other than just straight mathematics. Among the more popular pastimes is to play games. Here is a collection of six reader-generated calculator programs that should keep your calculator busy for some time. Four of these are games: "Dive Bomber" has you aboard a ship trying to shoot down a dive bomber before it blows you up; "Football" has you playing the game with six basic plays and random-number control of offense and defense effectiveness; in "Blackjack," you gamble against one or more opponents; and "Space Flight" has you piloting a spacecraft between and around two planets and gives you the option of landing if you wish. The last two programs are "scientific" in nature: In "Biorhythm Forecast," you forecast the physical, emotional, and intellectual behavior of yourself or anyone else for any given day or period; and in "Test Your ESP," you have the calculator "flipping a coin" and you make guesses based on your ESP.

All the programs presented here are written in RPN specifically for the Hewlett-Packard HP-25 programmable calculator. However, if you have another make or type of programmable calculator with the necessary functions, you can rewrite the programs to suit your own particular needs.

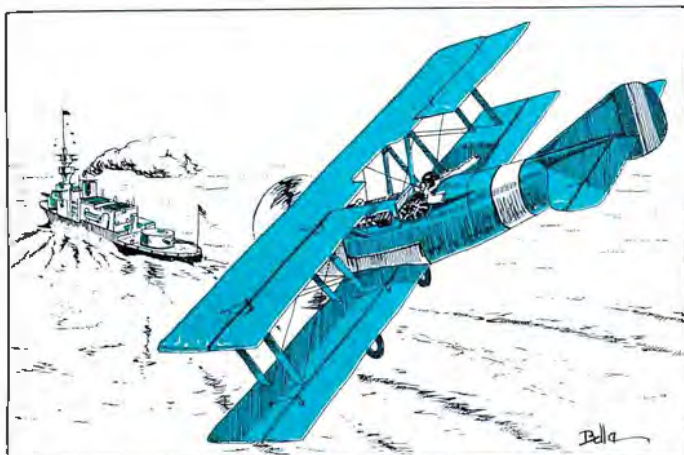


## SPACE FLIGHT

## BLACKJACK







# BATTLE THE DIVE BOMBER

● In this game, the goal is to shoot down a dive bomber with antiaircraft fire before it can bomb your ship. The initial range of the plane is known to be 1000 m but its speed can only be guessed to be between 100 and 200 m/s, thanks to the random number generation of the program. To zero in on the plane range, estimates are made for firing once a second as the plane approaches and range errors are fed back. However, range error is known only to within  $\pm 10$  m, which is close enough to hit the dive bomber with flak but not close enough to destroy it. This means essentially a direct hit ( $\pm 3$  m from the plane's center).

For the first range estimate, the average speed of 150 m/s is assumed to define a range of 850 m as shown in Fig. 1. When this range is run through the program, the calculator display will show the range error within  $\pm 10$  m. This error defines the approximate true range of the plane after the first second and also defines an approximate speed. Using this new data, the approximate range at the end of the next second is found for the new range setting. Repeating this

procedure, hits on the airplane will soon be made as indicated by a zero in the display. If a direct hit is made, 0.00000000 will be displayed.

Should the range close to zero, the plane's bomb will either hit the ship or, as 15% will, miss and hit the water. This probability is also controlled by a random number generator with a bias toward misses by higher speed planes. If the bombs hit the ship, the display indicates ERROR, and a miss is indicated by a 1.

Shown in Fig. 1 are each of the three possible conclusions that are reached through using the illustrated range finding technique for the first game run after storing the random number seed numbers shown. Since this seed number is stored only once per programming, the following games are controlled by the random selection of variables. The programming sequence is shown in Fig. 2 and the program-run sequence in Fig. 3.

Greater success can be achieved through more clever interpretation of error data variations and by slight variation in range once successive hits are at-

Seed number	.7	.5	.1
Initial range $R_0$	1000	1000	1000
Est. $\Delta R$ in 1s	150	150	150
Range setting	850	850	850
Range error	10	0*	40
True Range $R_1$	840	850	810
Est. $\Delta R$ in 1s, $(R_0 - R_1)$	160	150	190
Range setting	680	700	620
Range error	10	-10	0*
.	.	.	.
.	.	.	.
.	.	.	.
True Range $R_n$	670	10	30
Est. $\Delta R$ in 1s, $(R_{n-1} - R_n)$	170	140	200
Range setting	500	0	0
Range error	00...0(1)	Error(2)	1(3)

\* Plane hit

(1) Plane destroyed

(2) Ship sunk

(3) Ship missed

**Fig. 1. Possible conclusions for three random seed numbers.**

Display Line	Key Entry	Comments
00		
01	STO 7	
02	f FIX 0	
03	EEEX	
04	3	Initial range
05	STO 2	
06	E $\rightarrow$	
07	RCL 0	
08	+	
09	5	
10	f $y^x$	
11	E FRAC	
12	STO 0	
13	1	
14	+	
15	EEEX	
16	2	
17	X	Speed scale
18	CHS	
19	STO 5	
20	RCL 5	
21	STO + 2	
22	RCL 7	
23	RCL 2	
24	g $x < 0$	
25	GTO 43	
26	-	
27	STO 6	Range error
28	g ABS	
29	3	
30	f $x \geq y$	Destroyed?
31	f FIX 9	
32	RCL 6	
33	1	
34	0	
Registers		
$R_0$ Random number	35	÷
$R_1$ Empty	36	f INT
$R_2$ True range	37	1
$R_3$ Empty	38	0
$R_4$ Empty	39	X
$R_5$ - (Speed)	40	R/S
$R_6$ Range error	41	STO 7
$R_7$ Range setting	42	GTO 20
	43	RCL 0
	44	.
	45	8
	46	5
	47	f $x \geq y$
	48	GTO 34
	49	1
		Hit ship
		Missed ship

**Fig. 2. Dive bomber program.**



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEY ENTRY	OUTPUT DATA/UNITS
1	Key in program			
2	Store random number seed	$C < n \leq 1$	STO 0	
3	Initialize		f PRGM	
4	Key range estimate, computer range error	R	R/S	Range error
5	Repeat step 4 until conclusive result			Result
6	To start a new game, go to step 3.			

tained. Alternately, the odds can be varied to initially get the feel of the game or to increase the challenge. The easiest to vary are the destruct radius on line 29 and the fraction of bombs that hit on lines 44 through 46. The speed scale of lines 15 and 16 and the initial range of lines 3 and 4 can also be varied but only so that these entries take two steps each in the program.

—Jerald Graeme

Fig. 3. Dive bomber program-run sequence.



## FOOTBALL

● Game rules define a field from a zero-yard line to a 100-yard line, with one player's goal at each end. For a touch-down, the ball must be moved to a position less than zero or greater than 100 as monitored by the calculator display. The team in possession is defined by a stored ID number. Six basic plays are possible: kickoff, run, pass, punt, conversion, and field goal. By skillfully mixing these plays, the best strategy can be found for a given set of stored play-effectiveness characteristics.

To begin the game, numbers are stored to set the average effectiveness of the defense, the probability of an incomplete pass, and a yardage gain multiplier. Typical numbers are in the instructions in Fig. 1. Control is also possible over the average characteristics of kicks and kickoffs with the steps noted in the program. Actual gain or loss on the play will be determined by a random number multiplier and by a second random number that is compared against the defense and pass probabilities. For the kickoff, the ball is placed on the 20 or 80 yard line by storing that number in the zero register; and the team in possession is defined by storing an ID number 1 or a -1 in the 6 register (see Fig. 2). Results of the kickoff will be displayed by an operating pause showing the gain

Display Line	Key Entry	Comments	Display Line	Key Entry	Comments
00			31	GTO 41	
01	RCL 4		32	1	
02	$\pi$		33	3	Kick
03	+		34	STO + 5	characteristics
04	$e^x$		35	2	
05	PRGM	1st random number	36	GTO 42	
06	RCL 4		37	RCL 4	
07	X		38	RCL 1	
08	2		39	$x \geq y$	
09	-		40	GTO 43	Good defense
10	STO 5		41	4	Poor defense
11	PRGM		42	STO X 5	
12	ARC	2nd random number	43	RCL 5	
13	STO 4		44	INT	
14	$x \leq y$		45	Pause	Gain or loss
15	$x - y$		46	RCL 6	
16	GTO 37	Run	47	X	
17	$x < 0$		48	STO + 0	
18	GTO 32	Kick	49	RCL 0	Yardline
19	2				Registers
20	$x = y$			R <sub>0</sub>	Yardline
21	GTO 28	Kickoff		R <sub>1</sub>	Defense probability
22	STO X 5	Pass		R <sub>2</sub>	Pass incomplete probability
23	RCL 4			R <sub>3</sub>	Gain factor
24	RCL 2			R <sub>4</sub>	Random number
25	$x < y$			R <sub>5</sub>	Gain or loss
26	GTO 37	Pass complete		R <sub>6</sub>	Player I.D. (+1 or -1)
27	GTO 44	Pass incomplete			
28	1				
29	1	Kickoff characteristics			
30	STO + 5				

Fig. 1. Program for football game.



STEP	INSTRUCTIONS	INPUT	
		DATA/UNITS	KEY ENTRY
1	Key in program		
2	Set display		f FIX 0
3	Store defense probability		0.8 STO 1
4	Store pass incomplete probability		0.3 STO 2
5	Store gain factor		14 STO 3
6	Store random number seed	$0 < n < 1$	n STO 4
7	Store team ID	A(1)	A STO 6
8	Place ball if appropriate	B(2)	B STO 0
9	Key play code, compute gain or loss on play	C(3)	C R/S
10	Repeat 9 until ball changes hands or must be placed, then repeat Step 7 or 8.		

Fig. 2. Football program-run instructions.

Team's Goal Line	A	Play	B	Play	C
0	1	Kickoff or follow-	20	Kickoff	2
100	-1	ing kickoff or	80	Pass	1
		beyond goal	10 or 90	Run	0
		Conversion		Punt, conversion or field goal	-1

or loss on the play, then a stop at the resulting ball possession.

The receiving team's ID number is stored and plays are called by keying the code numbers of the instructions. This continues until a touchdown is made or possession is lost through failure to make the first-and-ten, by punt or by a field-goal attempt. Successful field goals and conversion kicks are indicated by a ball landing 15 yards inside the goal line. Progress toward a first-and-ten is monitored by the player.

Thanks to random-number influence, it is strategy that wins this game of football. Depending on player preferences, the program can be set up for a better passing game, better running game, tougher defense, etc.

—Jerald Graeme



## BLACKJACK

● The decision-making capability of the HP-25 lends itself to solving complex algorithms that heretofore required a computer to solve. The calculator has several conditional branching instructions that allow the sequence of the program execution to be altered based on the outcome of a test on the contents in the X and Y registers. If the answer to the test is YES, the program continues sequentially downward; if NO, the program branches, bypassing the next and continuing on to the following step. This is what is done when playing "Blackjack" (or "21").

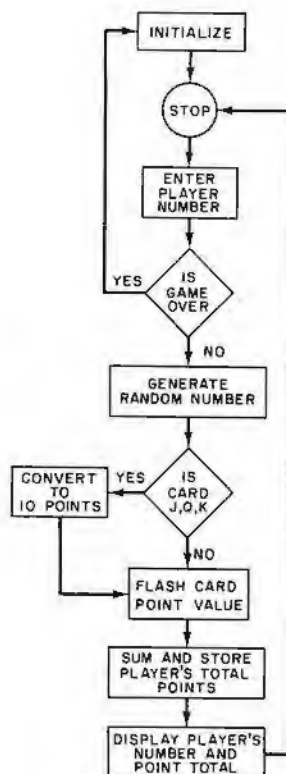
To play Blackjack, each player "draws" two or more cards, the point values of which are stored in memory. Numbered cards are worth their face values; the Jack, Queen, and King are worth 10 points each; and the Ace is scored as 1 or 11 at the player's option.

Display Line	Key Entry	Display Line	Key Entry	Registers
00		25	R↓	
01	CLX	26	f FIX 0	R <sub>0</sub> Working player's number
02	STO 1	27	f PAUSE	
03	STC 2	28	f PAUSE	
04	R/S	29	f FIX 2	
05	$\frac{x}{y}$	30	EEEX	
06	STO 01	31	2	
07	STO 0	32	÷	
08	RCL 3	33	STO 5	R <sub>1</sub> Score of Player 1
09	$\frac{x}{y}$	34	RCL 0	
10	+	35	2	R <sub>2</sub> Score of Player 2
11	5	36	f x = y	
12	f y <sup>x</sup>	37	GTO 42	R <sub>3</sub> U <sub>0</sub>
13	$\frac{x}{y}$ FRAC	38	RCL 5	R <sub>4</sub> 13
14	STO 3	39	STO + 1	R <sub>5</sub> Last Card
15	RCL 4	40	RCL 1	
16	X	41	GTO 45	R <sub>6</sub> 10
17	f INT	42	RCL 5	
18	1	43	STO + 2	R <sub>7</sub> 12
19	f x ≥ y	44	RCL 2	
20	GTO 48	45	RCL 0	
21	R↓	46	+	
22	RCL 7	47	GTO 04	
23	f x = y	48	RCL 6	
24	GTO 48	49	GTO 26	

Fig. 1. Blackjack game program.



Fig. 2. Flow chart for the blackjack game.



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEY ENTRY	OUTPUT DATA/UNITS
1	Key in program			
2	Initialize			
	Store $U_0$ ( $0 \leq U_0 \leq 1$ )	$U_0$	STO 3	
	Store constant	13	STO 4	
	Store constant	10	STO 6	
	Store constant	12	STO 7	
3	Key in player's #	1 or 2	f PRGM R/S	0.00
			R/S	Flashes card value. Displays player # and his total
4	Perform Step 3 until game is over			
5	To end the game	0	R/S	0.00
6	For new game, go to Step 3.			

The winner of the game is the player who scores closest to, but does not exceed, 21 points. The game program and its flow chart are shown in Fig. 1 and Fig. 2, respectively.

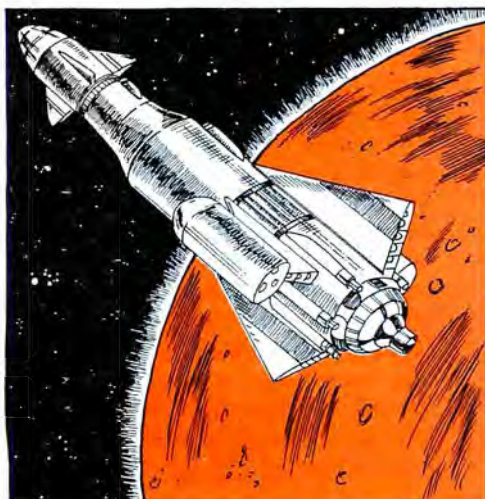
**The Program.** To form an endless "deck" of 14 cards, a pseudorandom number generator is programmed from the equation  $U_i = \text{fractional part of } (\pi + U_{i-1})^5$ . The starting value,  $U_0$ , of the sequence is chosen such that  $0 \leq U_0 \leq 1$ . This forms a sequence of random numbers. When  $U_i$  is multiplied by 13, a card value from 0 through 12 is obtained. The point value of the card is the integer part of 13 multiplied by  $U_i$ . This random generator occupies steps 08 through 17 in Fig. 1.

Since no numbered card has a point value of 0, 1, or 12, the Jack, Queen, and King are assigned these numbers. The program uses conditional branching to test for their presence and converts them to a value of 10 points as needed. This is illustrated in program steps 19 and 23. If the answer to step 19 or step 23 is YES, execution continues downward and the program jumps to a subroutine at step 48. If the answer is NO, the program skips the following step and continues. The remainder of the 49-step program sets the display to flash the generated "card" and display the player's number and point total.

Instructions for running the program are given in Fig. 3. If an Ace is generated (11 points), the player can keep track of it mentally and elect to use it as 1 point by subtracting 0.1 from his score register. If at any time the player forgets his total score, he can find it in register R1 or R2. The last card can be found in register R5.

—Dale G. Platteter

Fig. 3. Instructions for running blackjack program.

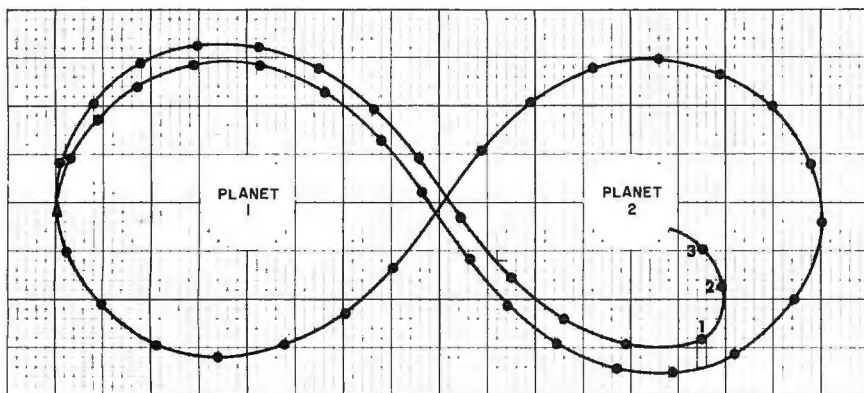


## SPACE FLIGHT

● This program performs the calculations required to describe how an object (spacecraft) would move about in relation to two bodies (planets) of chosen sizes. No fancy display is needed; all you need are a programmable calculator, graph paper, and a pencil. The calculator tells you where the spacecraft is at any given time. You can "fly" the spacecraft yourself by inserting commands to accelerate or decelerate along the way. You can even land the spacecraft on one of the planets. And if you should crash it, the calculator tells you how hard you hit the planet.

**Program Instructions.** Choose a





**Fig. 1. Starting positions:**  $x = -2$ , STO 0;  $y = 0$ , STO 1. **Starting velocities:**  $x = 0$ , STO 2;  $y = .45$ , STO 3. **Planet 1 radius .5, STO 4. Planet 2 radius .5, STO 5. Planet 2 = 4 divisions (step 24). Burns:** 1 =  $-.3$ ; 2 =  $-.3$ ; 3 =  $-.4$ . **Final velocity:** .43 (ouch!).

starting point on the graph paper (see Fig. 1), which is the location of planet 1 and the point of origin of the horizontal (X) and vertical (Y) axes of the two-dimensional space in which you will be flying. When you move to the right, X increases in the positive direction and when you move upward, Y increases in the positive direction. For example, a point two divisions to the right and one division up would be labelled X2, Y1. When you move to the left or downward, the numbers do the same but are prefixed by minus signs.

Program the calculator as shown in Fig. 2. Key a 1 into step 12 and a 4 into step 24. Switch to the run mode, fix the

display at two places, and return to address 00. The calculator is now ready to accept starting data.

We will use the data illustrated in Fig. 1 to demonstrate how a program works. Note that the two planets are of equal size. (Different-size planets can be used simply by specifying different radii for each.) Here, the radii are 0.5, which are keyed into registers 4 and 5. Planet 2 is located to the right of planet 1 by 4 divisions, although the two can be separated by any number between 1 and 9. It helps to draw appropriate-size circles on the graph paper at the selected planet locations. This helps you visualize how close you are getting to a landing.

Display Line	Key Entry	Comments			
00		Set flag 0	28	GTO 06	body 2 radius.
01	0	Get distance to	29	RCL 3	Return to V + A
02	RCL 1	body 1	30	STO + 1	
03	RCL 0		31	RCL 2	
04	P→	Convert to radial	32	STO + 0	P + (V + A)
05	RCL 4	distance. Get	33	P→	Get direction
06	$x \geq y$	body radius.	34	$x \neq y$	of travel for use
07	GTO 46	If distance < radius	35	STO 6	in input routine
08	$x \neq y$	show crash velocity.	36	RCL 1	Get Px, Py
09	$x^2$		37	RCL 0	
10	1/x	$G = 1/R^2$	38	R/S	Display, take input
11	X	$G = 1/R^2 \times \text{Mass}$	39	RCL 6	
12	(N)		40	$x \neq y$	
13	÷	Scale factor	41	R→	Add input to
14	R→	x,y format	42	STO + 2	previous velocity.
15	STO - 2	Increment velocity	43	$x \neq y$	
16	R↓	by acceleration	44	STO + 3	
17	STO - 3		45	GTO 01	Return to gravity
18	R↓	Test flag, body	46	RCL 3	routine.
19	$x \neq 0$	1 or 2?	47	RCL 2	If crash, get
20	GTO 29	Go to P + (V + A)	48	P→	last velocity,
21	1	Set flag 1	49	FIX 9	display in 9 digit.
22	RCL 1	Get distance to			
23	RCL 0	body 2 by incre-			
24	(N)	menting along x			
25	-	axis by (N).			
26	P→	Convert to radial			
27	RCL 5	distance. Get			

**Fig. 2. Space flight program.**

Starting position and velocity of the spacecraft are inserted into registers 0 through 3. Placing an arrow to indicate the direction of travel at this point also helps in the visualization. These initial inputs simply start off the flight. Hereafter, there is a lot of moving about as time passes, owing to the gravities of the planets and the fact that you can command a change in speed at any time.

To start the flight, press R/S. What happens now is what would happen in space: Both planets attempt to attract the spacecraft, whose inertia tries to carry it forward, and the forces bring the craft to the position indicated when the program stops. The X coordinate is displayed first. To obtain the Y coordinate, press X↔Y. Make a dot at this point on the graph. Before starting again, press 0. This is necessary because the calculator is awaiting instructions from you on speed changes and will interpret the displayed number as such when it begins to step through the program again.

If everything goes okay, the spacecraft will fly a figure-8 around the planets forever. However, should you wish to land, insert a decelerating "burn" instead of 0 ( $-0.3$  should do) and start again. The spacecraft will now begin to dip toward the nearest planet. If you are not careful, the craft will hit the surface hard. As you approach the surface of the planet, you must make your burns larger and larger. However, if you make them too large, you will begin to take off again, usually in an unexpected direction. Remember that the sign of the burn indicates an increase (+) or decrease (−) in speed along the direction of travel. So, if you observe that you have moved back from your last position and wish to keep receding from the planet's surface, you must key in + burns from then on. Lots of practice here helps.

If you should successfully touch down, the calculator indicates this by switching to a nine-digit display of the last velocity. Numbers greater than about 0.25 cannot really be called "touchdown."

To initiate a new flight, simply switch back to a two-digit display format, insert new position and velocity information, and press R/S. The planet positions and radii are not affected by running the program again. If you choose to use different-size planets or change the distance between the planets or both, you need only change step 24 and the contents of R4 and R5. Incidentally, flying with different-size planets is a real challenge, especially the landing phase.

—Paul Lutus

POPULAR ELECTRONICS





# BIORHYTHM FORECAST

● Rhythmic changes in human behavior follow predictable cycles. A person's physical, emotional, and intellectual behavior is said to change with the cycles that have been determined to be 23, 28, and 33 days in length, respectively. Knowing this, a general statistical forecast of individual behavior can be made. This is what the calculator program described here does; it can tell you where you are in each of the three cycles for a chosen day.

As each of the cycles passes from one extreme to the other, you might experience days during which your abilities decline and be more likely to be involved in accidents. (Enough credibility is attached to this theory to make many companies forecast by computer biorhythms for their employees to warn them of their "critical days.")

The biorhythm cycles are said to begin at birth and, like built-in "clocks," follow us through life. The only information needed for running the Biorhythm Forecast program is your birthdate and the day to be forecast. The program first determines and displays the number of days between the two dates and then your position in each of the three cycles. The program itself is shown in Fig. 1. A circular graph, or Biorhythm Wheel (Fig.

2), can then be used to visualize the results and to spot upcoming critical days during which one or more of the cycles pass through the median line at the center. A day is said to be "super-critical" if two or three of the cycles rest in the median area at the same time.

**Program Instructions.** Load the program into your calculator as shown in Fig. 1. Then return the calculator to address 00. Insert the two constants used by the program by keying in 36525, STO, 5 and 30.55, STO, 6. Now, insert your birthdate in register 1 with the format month-month.day-day year-year. (For example, April 3, 1947 would be inserted as 4.0347, STO, 1.) Then insert the forecast date, using the same format, in register 2.

Be sure to return the calculator to address 00 and set the program to the run mode by operating the R/S key. When the program stops, the display will show the number of days between the two dates. Now key in 23 and operate the R/S key. The display will now have a number between 0 and 1 in it, which can be marked on the Biorhythm Wheel. (The use of the letters P, E, and I will help in marking the positions on the Wheel.)

For the emotional cycle, enter 28, R/S and for the intellectual cycle, 33, R/S. Mark these on the Wheel in the same manner.

When you are finished filling in your Biorhythm Wheel with the information generated by the calculator, numbers in the shaded area of the Wheel indicate a critical day. It is possible to foresee such days from a single forecast, such as a case where two cycles are in near-synchrony and moving toward the median (clockwise) in a group. You then key in two new dates, advancing the forecast a day, to clarify the situation.

When starting with new dates, always remember that the dates must be entered first, the program returned to address 00, and the R/S key operated. As written, the program works for dates in

Display Line	Key Entry
00	
01	0
02	STO 0
03	STO 3
04	3
05	RCL 1
06	$x < y$
07	GTO 11
08	2
09	STO - 3
10	R↓
11	INT
12	STO - 1
13	1
14	-
15	RCL 6
16	X
17	STO + 3
18	RCL 1
19	EEX
20	2
21	X
22	ENT↑
23	INT
24	STO + 3
25	-
26	RCL 5
27	X
28	STO + 3
29	RCL 0
30	$x \neq 0$
31	GTO 39
32	RCL 3
33	STO 4
34	STO - 3
35	RCL 2
36	STO 1
37	STO 0
38	GTO 04
39	RCL 3
40	RCL 4
41	-
42	STO 0
43	R/S
44	RCL 0
45	$x \neq y$
46	÷
47	FRAC
48	GTO 43

Fig. 1. Biorhythm program.

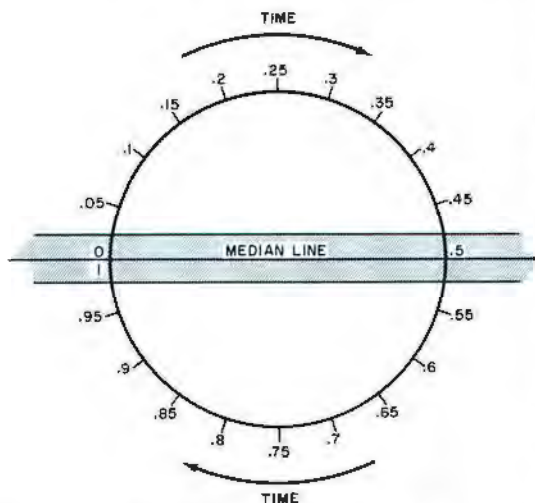


Fig. 2. Typical biorhythm wheel.



the 1900's. If you wish to use dates in a different century, the procedure to use is as follows. First, insert a new constant (3652500) in register 5. Now, the new date format is MM.DDYYYY (note the

four digits required for the year). Hence, June 8, 1846 would be entered as 6.081846. This format makes it possible to look into the biorhythms of historical figures whose dates straddle turns-of-

century. For example, who can resist the temptation to determine whether the Battle of Waterloo was fought on one of Napoleon's critical days?

—Paul Lutus



## TEST YOUR ESP

● Have you ever had a strong hunch about something that later occurred exactly as you expected it to? Are you considered "lucky" by your friends? If so, maybe you have ESP (extrasensory perception). This program will help you to determine if you do.

The program electronically "flips a coin" and then compares your guesses with the results. It tells whether or not your guesses were correct and records the score for future use. After you have made a number of guesses and think you are doing pretty good, you can use the program to calculate the quality of your ESP.

**Program Instructions.** Key the program into your calculator according to the steps detailed in Fig. 1. Then clear all registers and insert a number between 0.1 and 10 into register 0. (This is the "seed" number that initiates the coin-toss routine.) Reset to address 00, fix a nine-digit display format, and key in your first guess, pressing either 0 or 1, and press R/S. The program will run and finally stop with either your guess filling the display or "Error" if you guessed wrong. You can go on guessing like this as many times as you wish; the calculator automatically keeps score. When you want to find out how well you are doing, you can recall registers 1 (how many tries) and 2 (how many correct guesses), and you can use the built-in probability calculator to evaluate your performance.

Registers  
R<sub>0</sub> Seed N  
R<sub>1</sub> Runs  
R<sub>2</sub> Right guesses

Display Line	Key Entry	Comments
00		
01	77	
02	RCL 0	
03	.	
04	1	
05	y <sup>x</sup>	
06	FRAC	
07	STO 1	
08	1	
09	0	
10	X	Generate random number
11	INT	
12	2	
13	÷	
14	FRAC	
15	2	
16	X	
17	x = y	Compare with guess
18	GTO 25	
19	1	
20	STO + 1	
21	2	
22	COS <sup>-1</sup>	Wrong guess—"Error"
23	COE	
24	GTO 1	
25	1	
26	STO + 1	
27	STO + 2	
28	R4	
29	.	
30	4	
31	÷	Right guess—display
32	GTO 00	
33	2	
34	RCL 2	
35	RCL 1	
36	2	
37	÷	
38	-	
39	x < 0	Calculate probability
40	GTO 43	
41	y <sup>x</sup>	
42	GTO 00	
43	CHS	
44	y <sup>x</sup>	
45	CHS	

Fig. 1. Program above and right.

Most of us would think a score of 75 out of a possible 100 is great performance, but a scientist would ask what the probability is that your score could have come about by chance. To find out the probability factor, key into register 1 the number 100, into register 2 75, GTO 33, R/S. The answer is 33,000,000, which means that the probability that the result came about by chance is 1 in 33,000,000!

At any time during a session, you can find the probability of your efforts in the same manner, simply by pressing GTO 33 and R/S. You can then resume testing, since the program always returns to the point at which a guess can be made without disturbing the collected score. If a minus sign appears in the display of the probability rating, you are getting more incorrect guesses than correct ones. This sometimes happens in ESP research. It is called "negative" ESP.

If you are serious about testing your ESP, sit down with the resolve to make a certain number of guesses. Many ESP research programs get into trouble because subjects turn in "good" runs and throw away "bad" ones. Over a period of time, this makes the ESP ability appear to be better than it really is. So, you should always make the same number of guesses without stopping short of or exceeding the planned number. If you think you have ESP ability, keep a record of your runs. You can then total all the figures, insert them in registers 1 and 2, and calculate an overall probability for the series.

Always use a different "seed" number in register 0, since a given number will always result in the same sequence of 1's and 0's, which might be memorized.

—Paul Lutus



# PERFORMANCE CAPABILITIES OF 40-CHANNEL CB TRANSCEIVERS

*R-f power output and modulation capabilities  
of expanded-band transceivers are examined.*

BY BILL SCHERER\*

**R**UMORS have been circulating to the effect that the new 40-channel CB transmitters are not as "powerful" as those in former 23-channel transceivers. Deficiencies such as lower r-f output, low modulation, etc., are principally cited. To set the record straight, these statements are unfounded. As a matter of fact, even the FCC has seen fit to put these rumors to rest by issuing Public Notice No. 77385 titled "CB 40 Channel Power Limits Unchanged."

To make sure of the situation for ourselves, we tested three typical 40-channel AM transceivers and compared our results to those obtained with older 23-channel rigs. Two of the transceivers were mobile types, while the third was a base station. All three were FCC type-accepted.

**What the FCC Rules Say.** The FCC's technical regulations still hold for both 40- and 23-channel CB transceiv-

ers. Specifically, the r-f carrier output must be limited to 4 watts on AM, with modulation held to within 100% on both the negative and the positive peaks. Single-sideband output must be held to 12 watts maximum peak-envelope-power (PEP), and a means must be provided for preventing the modulation from exceeding this or the rated power of the transmitter.

In the past, FCC type acceptance was often predicated on the manufacturer's say-so. The manufacturer simply pre-

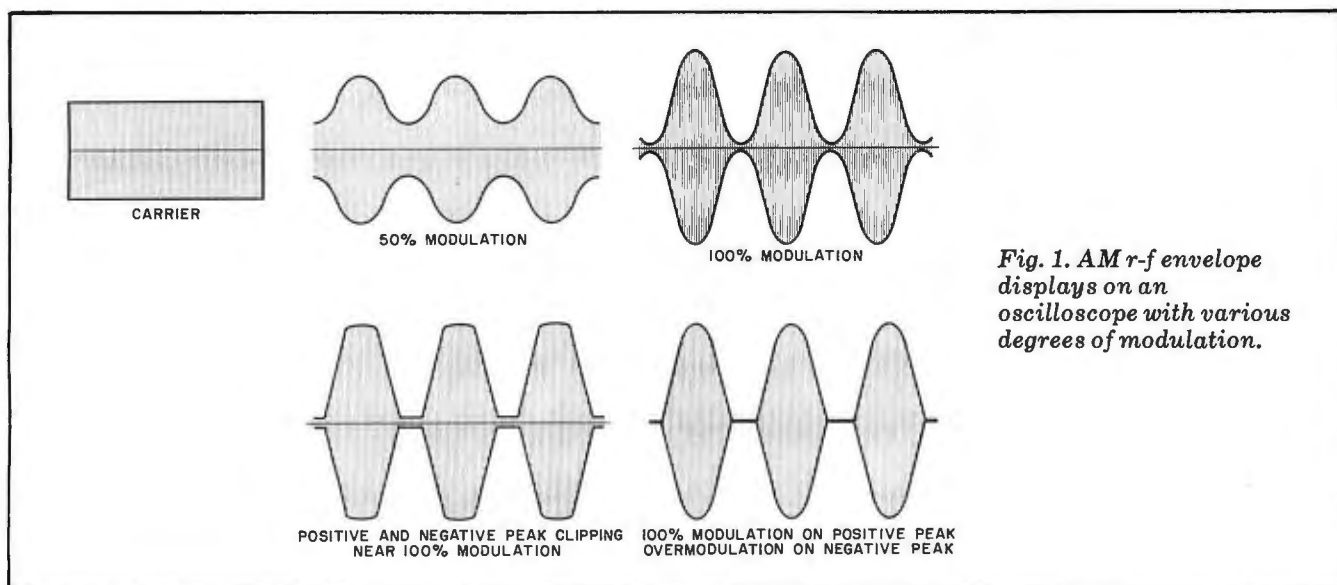
sented his data to the FCC and received type acceptance as a matter of course. The eventual result was that many AM transceivers never really met the regulation-specified parameters, although they reached the market with FCC approval. While these transmitters usually were within the 4-watt output power limit, severe overmodulation, particularly on the negative peaks, was often possible, especially when using "power" microphones. This caused clipping carrier breakup, which, along with frequently used compression, produced a somewhat higher average modulating power. The foregoing was obtained at the price of high distortion and severe adjacent-channel splatter,

Strict adherence to the modulation capabilities is now being enforced with the new 40-channel transceivers. Now, transceivers must undergo type-acceptance tests at the FCC labs or the equivalent labs in Japan. Any adverse perfor-

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\*Bill Scherer has been writing technical communication articles for more than 30 years. For nine years, he was Technical Director for CQ magazine, where he was responsible for the technical reports on amateur equipment. Since 1970, Bill has been the reviewer for all the CB transceiver reports that have appeared in POPULAR ELECTRONICS.





*Fig. 1. AM r-f envelope displays on an oscilloscope with various degrees of modulation.*

mance is no longer acceptable. This may have given rise to the false notion that the apparent average overmodulated power of older CB transceivers made them better than the new transceivers.

**What We Observed.** All three of the

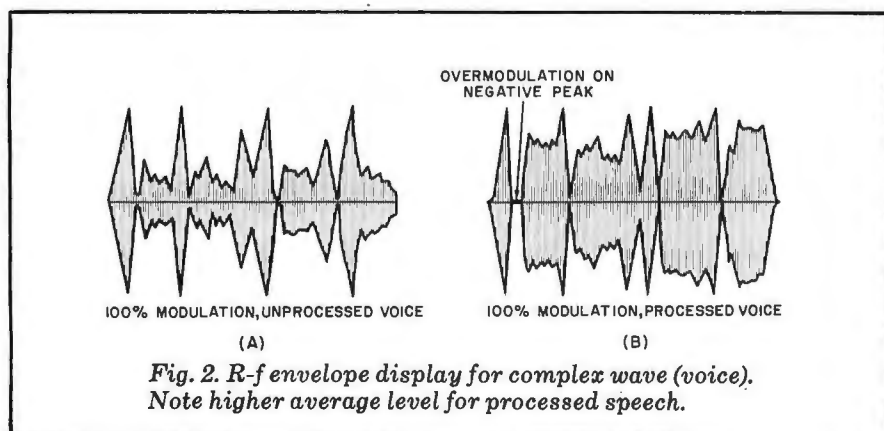
system at the microphone amplifier to hold the modulation on both peaks to just 100%. Even so, the excellent characteristics of the amc system allowed a very high average modulating power to be maintained within the required modulation limits, with very low distortion.

Transceiver A, but with occasional peaks to 100%. Again, a high average modulating level was obtained.

Transceiver C (another mobile rig) employed still another type of amc system that also yielded high average modulation with an occasional insignificant degree of overmodulation on the negative peak.

All three of our test transceivers produced a high degree of clean, average modulated output power. The output in all three cases was as great as, if not greater than, that of most of the older 23-channel transceivers. Furthermore, no matter how loud we spoke into the microphone, we observed the same results, and the adjacent-channel splatter held to within 60 dB down (at greater than  $\pm 5000$  Hz from the carrier frequency). Compare this figure with the 40-to-55-dB splatter figures obtained with many 23-channel transceivers of only last year and you will understand how much improved the new 40-channel transceiver designs really are.

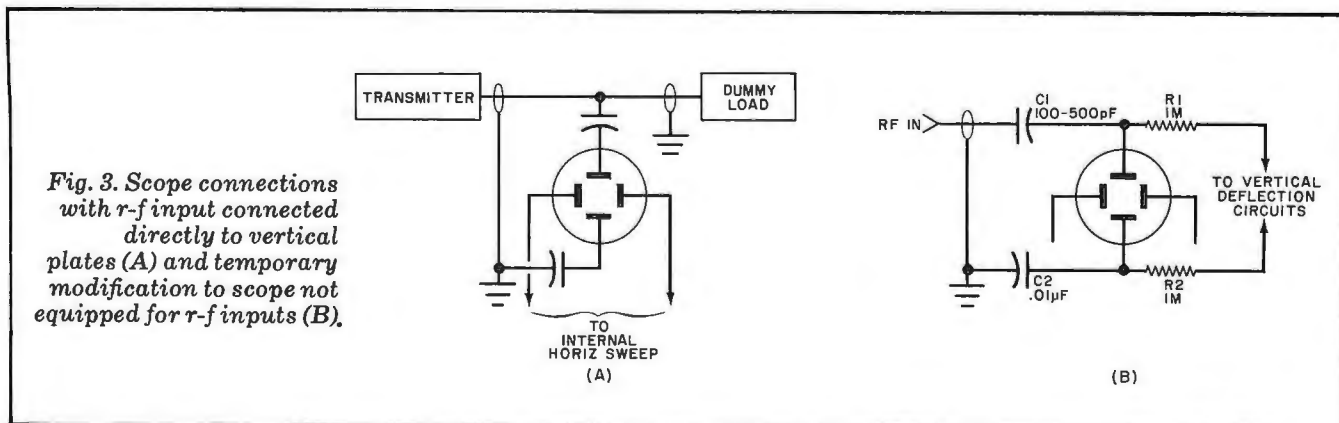
It should be noted that, for a given degree of relative average modulation, the aural difference between a 90% and a



*Fig. 2. R-f envelope display for complex wave (voice). Note higher average level for processed speech.*

40-channel AM transceivers we selected at random for our tests delivered 4 watts of r-f carrier output power. Transceiver A (mobile) employed a bootstrap automatic-modulation-control (amc)

Transceiver B (base station) employed a low-level audio-frequency clipper and a low-pass filter (to minimize distortion products) that produced results similar to those obtained with



*Fig. 3. Scope connections with r-f input connected directly to vertical plates (A) and temporary modification to scope not equipped for r-f inputs (B).*



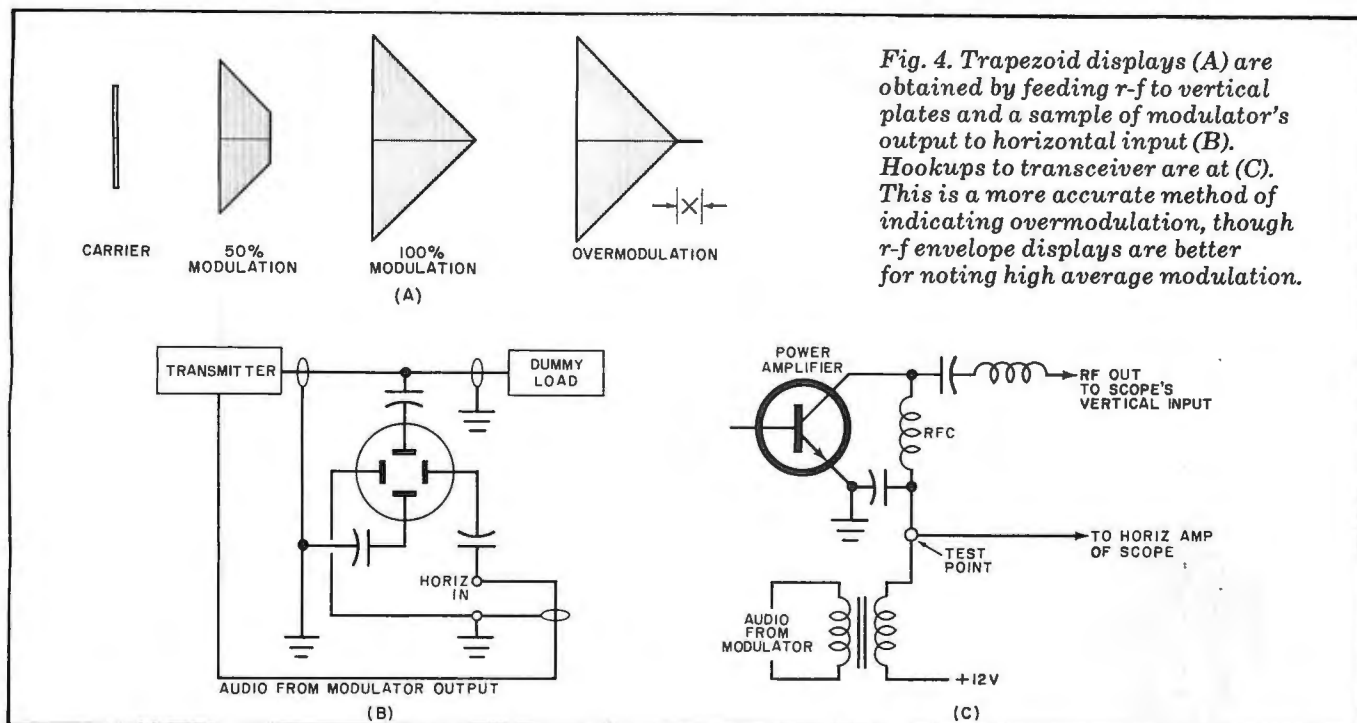


Fig. 4. Trapezoid displays (A) are obtained by feeding r-f to vertical plates and a sample of modulator's output to horizontal input (B). Hookups to transceiver are at (C). This is a more accurate method of indicating overmodulation, though r-f envelope displays are better for noting high average modulation.

100% modulated signal is minimal and insignificant. It amounts to less than 0.5 dB. Therefore, if your transceiver does not always quite reach a 100% modulation level, there is no need to be particularly concerned.

If you want more power (and range), you can always communicate via SSB, which is a considerably more efficient medium than AM. For a given expended power, SSB gives an effective signal-level increase of up to 9 dB over AM. This translates into an eight-fold relative power improvement, which is equivalent to raising the 4-watt output power of an AM transmitter to 32 watts. Additionally, by engaging the USB or LSB mode, a 40-channel transceiver yields up to 80 possible SSB communication channels, thereby saving spectrum space and thus alleviating user crowding.

#### Viewing Modulation Waveforms.

Now let us see how various modulating conditions are displayed on the CRT of an oscilloscope. Typical r-f envelope patterns for a carrier modulated with a steady-amplitude, single-frequency test

tone are shown in Fig. 1. The waveforms in Fig. 2 illustrate the display for a voice-modulated carrier without (A) and with (B) speech processing. These waveforms can be displayed by feeding the transmitter's output (using a dummy load in place of the antenna) directly to the vertical deflection plates of an oscilloscope (see Fig. 3A).

If your oscilloscope does not have provisions for direct r-f input, you can make the appropriate connections temporarily with isolating resistors (to prevent r-f energy from backing up into the other circuits in your scope) as shown in Fig. 3B.

The waveforms shown in Fig. 4A illustrate a trapezoid display that is obtained by feeding the r-f directly to the scope's vertical-deflection plates and applying a sample of the modulator's output signal to the scope's ac-coupled horizontal input. (See Fig. 4B for details.) The hookups to the transceiver are illustrated in Fig. 4C. Note that the modulator signal is picked off the test point on the +12-volt power bus side of the choke (rfc) in the power amplifier's collector circuit. (If

the power-amplifier stage is emitter modulated, a similar test point in the emitter circuit is used for the modulator signal pickoff.) A test point is usually provided at the appropriate locations in the circuit.

The waveforms shown in Fig. 5 illustrate the r-f envelope displays of an SSB signal obtained with the scope setup shown in Fig. 3A. Two nonharmonically related test tones (such as 800 and 1800 Hz) are applied to the microphone input. Their levels are equalized to bring the displayed "valleys" together at the horizontal axis for this test.

**In Conclusion.** As you can see from the tests of three randomly selected new 40-channel AM CB transceivers (from different manufacturers), there are no real grounds for the rumors pertaining to inferior performance. This does not mean that every 40-channel CB transceiver exhibits top performance. There were, in truth, some models that performed poorly in the early FCC test program due to the zeal of some manufacturers to obtain quick FCC type acceptance. These models were generally warmed-over 23-channel designs which, in order to meet new FCC radiation and spurious response requirements, were less powerful than they should have been. (Lower than maximum power or modulation capabilities are not FCC test criteria.) But, by and large, the new transceivers are capable of superior performance when compared with the older 23-channel transceivers we have been using. ◇

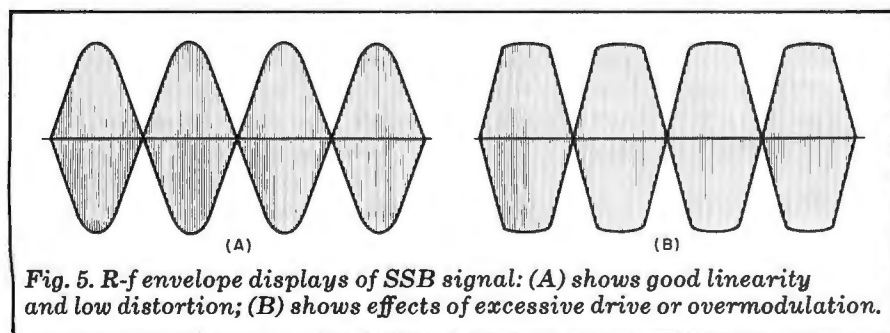
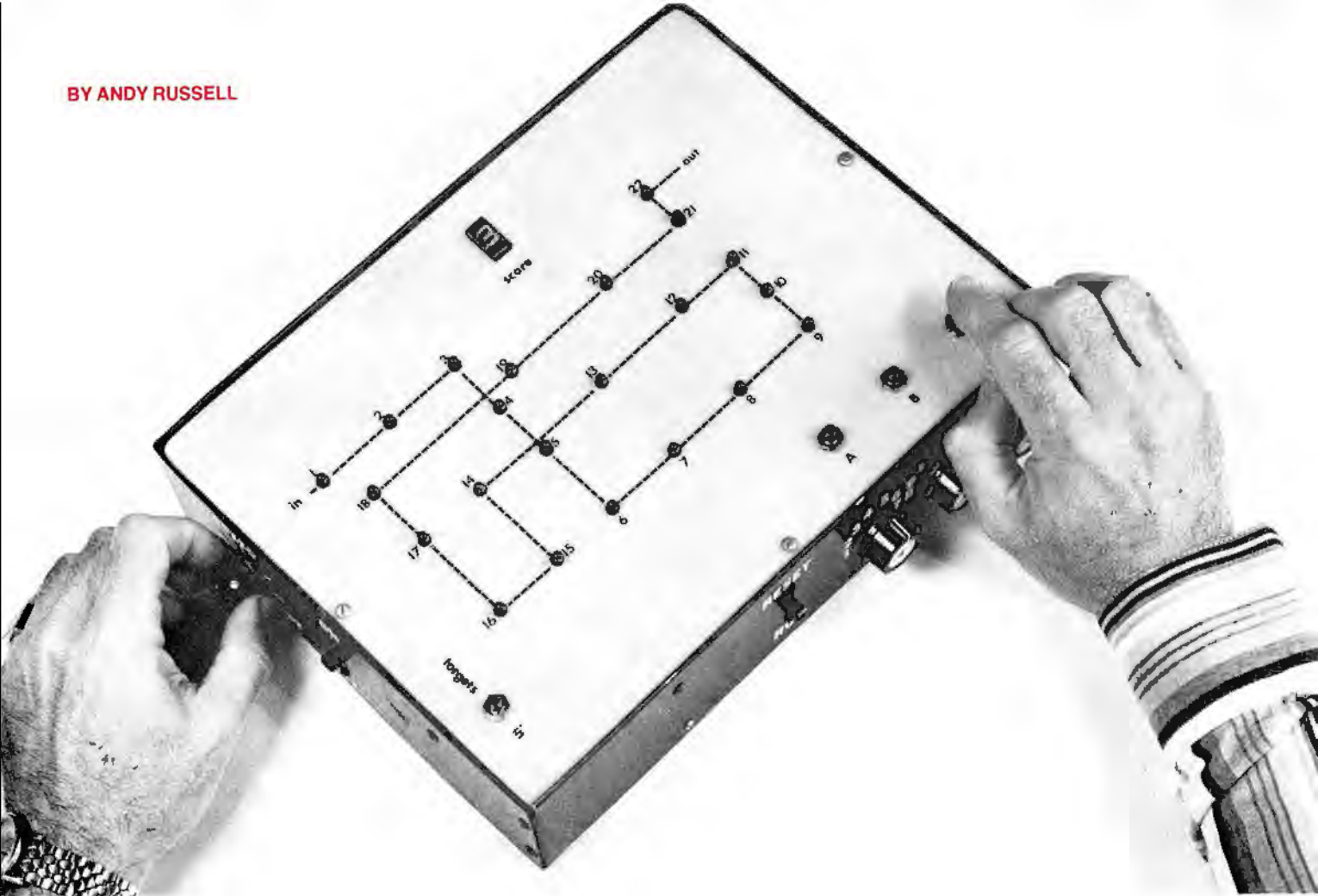


Fig. 5. R-f envelope displays of SSB signal: (A) shows good linearity and low distortion; (B) shows effects of excessive drive or overmodulation.





# BUILD THE LED TARGET GAME

*Test your "eye" and reaction time by trying to shoot a moving target.*

**T**HE LED Target Game consists of 22 LED's numbered sequentially along a random track with a circuit to control them so that one LED at a time turns on in sequence to give the appearance of a single glowing LED moving along the track. The person who is the first player can select the speed at which the glowing LED moves. He can also initiate the trip and cause more than one glowing LED to appear on the track to complicate the game. These moving, glowing LED's become targets.

The person who is the second player can select three positions (via three rotary switches) at which he will attempt to

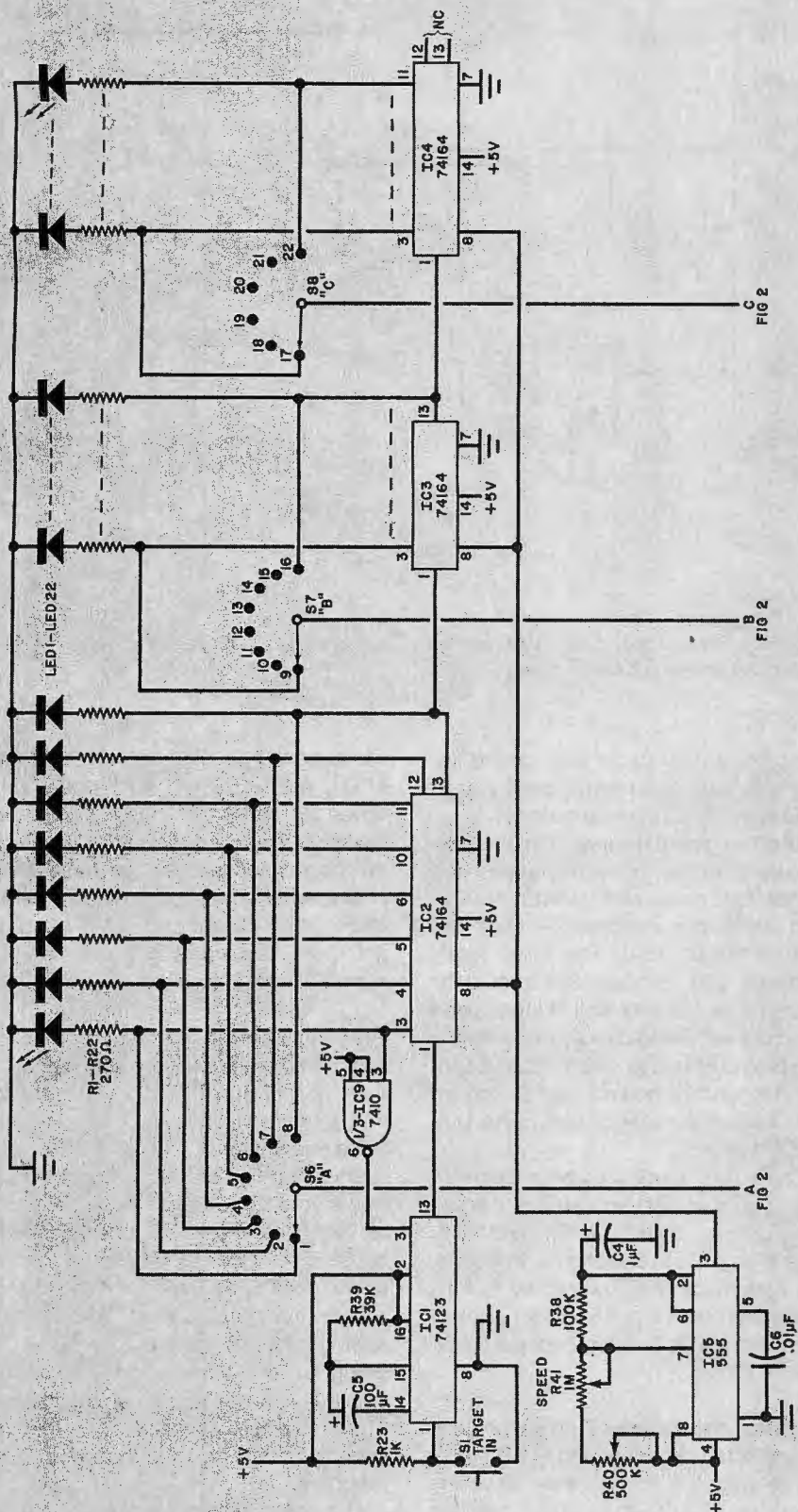
hit the targets. Thus, when the LED at a selected position glows, he operates a pushbutton associated with that position and, hopefully, "shoots" the LED. As each coincidence is made, a conventional decade counter using a 7-segment readout accumulates the hit score. Several rules for playing the game are suggested in this article, but they can be modified as wished by the players.

**How It Works.** Timer IC5 (Fig.1), is a variable-rate clock generator whose frequency can be set between 0.8 and 6 Hz via front-panel potentiometer R41. The timer pulses are applied to the clock in-

puts of three serial-in, parallel-out 8-bit shift registers IC2, IC3, and IC4.

The three shift registers are connected in series so that when a "1" is inserted into the serial input of IC2, it will be propagated down the three shift registers at the clock frequency. The "1" is inserted into IC2 by operation of one-shot IC1 by S1, the TARGET IN switch.

As each output of each shift register goes high, it applies current to an associated LED via a current-limiting resistor. Thus, as the "1" propagates down the line, each of the 22 LED's will be illuminated in turn, at a rate determined by the selected clock speed.



## PARTS LIST

- C1, C2, C3—10- $\mu$ F electrolytic capacitor  
 C4—1- $\mu$ F tantalum capacitor  
 C5—100- $\mu$ F electrolytic capacitor  
 C6—0.01- $\mu$ F capacitor  
 DIS1—Common-anode 7-segment display  
 IC1—74123 dual one-shot  
 IC2, IC3, IC4—74164 serial-in parallel-out 8-bit shift register  
 IC5—555 timer  
 IC6, IC7, IC8—74121 one shot  
 IC9—7410 triple 3-input NAND gate  
 IC10—7400 quad 2-input NAND gate  
 IC11—7490 decade counter  
 IC12—7446 BCD-to-7-segment decoder driver  
 LED1 through LED22—Conventional red LED  
 R1 through R22—270-ohm, 1/4-W, 5% resistor  
 R23 through R27—1000-ohm, 1/4-W, 5% resistor  
 R28 through R34—220-ohm, 1/4-W, 5% resistor  
 R35, R36, R37, R39—39,000-ohm, 1/4-W, 5% resistor  
 R38—100,000-ohm, 1/4-W, 5% resistor  
 R40—500,000-ohm trimmer potentiometer  
 R41—1-megohm potentiometer  
 S1 through S4—Normally open pushbutton switch  
 S5—Spst switch (or half of a dpst switch)  
 S6, S7, S8—Single-pole 8-position rotary switch  
 Misc.—Suitable cabinet and plastic top (approximately 12" by 9"), knobs (4), battery holder (4 D cells), hookup wire, dry-transfer lettering, etc.

*Fig. 1. Timer IC5 clocks a "1" generated by IC1 down the three series-connected shift registers, whose outputs drive LED's. Three switches allow selection of any LED in either shift register.*

One of the eight outputs of IC2 can be selected by rotary switch S6, one of the eight outputs of IC3 can be selected by S7, and one of the six outputs from IC4 can be selected by S8.

As shown in Fig. 2, each of these

switch outputs is passed to a two-input NAND gate with the other gate input coming from an associated one-shot. Since each NAND gate will have a zero output when both inputs are high at the same time, it takes a coincidence be-

tween the switch-selected input and the associated one-shot firing when it's pushbutton switch is operated.

The three coincidence NAND gate outputs are fed to a single 3-input NAND (IC9) whose output is used to drive dec-



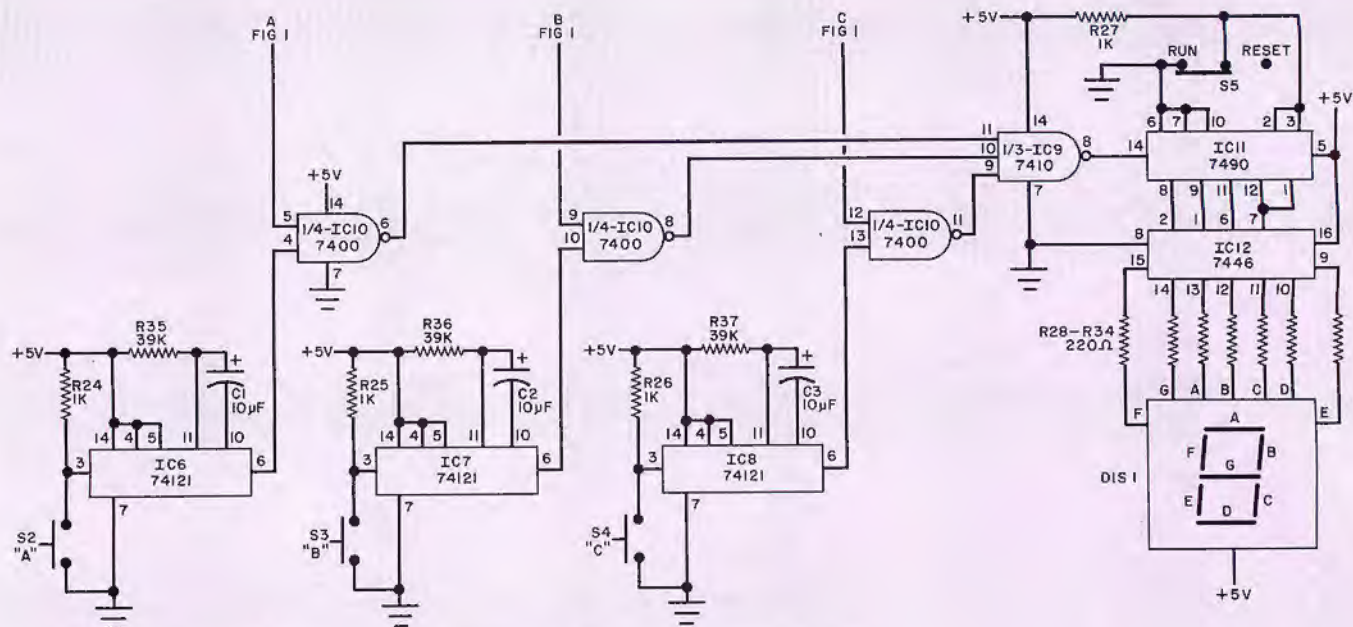


Fig. 2. Each selected LED line is coincidentally NAND gated, with each coincidence added on a decade counter, seven-segment LED readout.

ade counter IC11. This counter is connected to a conventional BCD-to-7-segment decoder IC12 that in turn drives a 7-segment common-anode LED display (DIS1).

When playing the game, each switch (S6, S7, and S8) is set to a particular LED output line before the TARGET IN switch (S1) is operated. When the LED's start their sequential action, switches S2, S3 and S4 must be depressed just when the selected LED comes on. If a coincidence is made, then a count will be entered in the decade counter and displayed on the readout. Holding S2 through S4 down constantly will not work since their associated one-shots will work only once for each switch depression.

**Construction.** The electronic circuit, other than the various switches, LED's, and DIS1, can be assembled on a piece of perforated board using sockets for all IC's. Make suitable connector pins so that the LED's and DIS1 can be connected to their respective current-limiting resistors.

In the prototype, the main "playing field" was made from a 12" by 9" piece of plastic, that was fitted into some form of supporting framework. The top of the playing field was marked with a random track (see photo) with each of the 22 LED's mounted within tight-fitting holes placed along the random track. LED1 should be at the beginning of the track, and LED22 at the end. Using press-on

type, mark the track with dotted (or dashed) lines and clearly identify each LED from 1 to 22 in the sequence.

The 7-segment display should also be mounted on the upper surface of the plastic top, along with TARGET IN (S1), and pushbutton switches "A" (S2), "B" (S3), and "C" (S4). The three rotary switches (S6, S7 and S8) should be mounted on the side wall of the support structure with each directly under its associated pushbutton switch. Speed control R41, and the power on-off switch are mounted on the side closest to the TARGET IN switch.

The power supply can be a simple 5-volt regulated system using a 6.3-volt transformer, diode rectifier and filter driving any 5-volt regulator IC. If desired, the system can be powered by four D-cells mounted in a plastic holder, using a 0.47-ohm series resistor to drop the voltage to 5 volts.

**Testing the Game.** Turn on the power and note that some of the LED's may be lit, with the lit sequence travelling along the 22-LED chain until it reaches LED22. Place RUN/RESET SWITCH (S5) to the RESET position and note that DIS1 indicates a zero. Set S5 to RUN. Position the three rotary switches (S6 through S8) to some selection of LED'S. Switch S6 selects from LED positions 1 through 8, S7 from 9 through 16, and S8 from 17 through 22.

With SPEED control R41 set for a slow speed (maximum resistance), operate

the TARGET IN pushbutton. Starting with LED1, each LED will illuminate in turn down the series. When the LED at the switch selected position glows, operate the associated pushbutton switch. If a coincidence is made, the readout will indicate a hit. Speed control R41 can be set from fast to slow, and can be trimmed as desired by R40.

**Playing the Game.** Two players are suggested, one to set the speed and initiate the LED travel, and the other to set the rotary switches and operate the three pushbuttons.

Once the first player initiates the LED travel, it is up to the other player to set his switches and hit his pushbuttons to cause a coincidence. Of course, the first player can initiate more than one LED at a time, but in the interests of sanity, he should not have more than three LED's going at one time. They should be spaced some selected numbers apart. The first player can also set the travel speed, or vary it while the game is in progress.

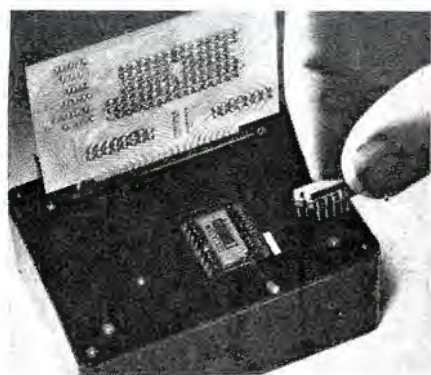
The second player pre-selects his numbers before any targets are sent through, and the first player should not see which positions have been selected.

The game is played in four quarters of 10 targets each with each "hit" called out on the readout. At the end of each quarter, the two players change places and play again. The winner is the player that has the highest cumulative score out of 40 targets. ◇



## TEST INSTRUMENTS

- BUILD A DIGITAL IC TESTER
- GUIDE TO OSCILLOSCOPES
- A 40-MHZ FREQUENCY COUNTER PROJECT
- ACCURATE MILLIAMMETERS ON A BUDGET



## BUILD A DIGITAL IC TESTER

*Inexpensive project tests DTL and TTL IC's.*

BY R. M. STITT

**T**ESTING digital integrated circuits has posed a problem to experimenters ever since the devices were made available at the hobbyist level. After all, many hobbyists were not about to spend thousands of dollars for a commercial,

general-purpose digital IC instrument. The tester presented here, however, can be constructed for just a few dollars and provide quick and accurate checks of 14- and 16-pin DTL and TTL IC's.

The operating principle is simple. Logic states of the questionable IC are compared to one of the same type that's known to be good. A testing program is set up via patch cords and the IC's are plugged into their respective sockets, at

which time the unit automatically runs through the program. Even the most complicated test program will be performed about 40 times per second.

A good/bad LED indicates the overall status of the device. Furthermore, 16 LED's (one for each pin) isolate faults to specific pins so that bad sections or functions can be detected. These fault LED's are also useful for debugging test programs.

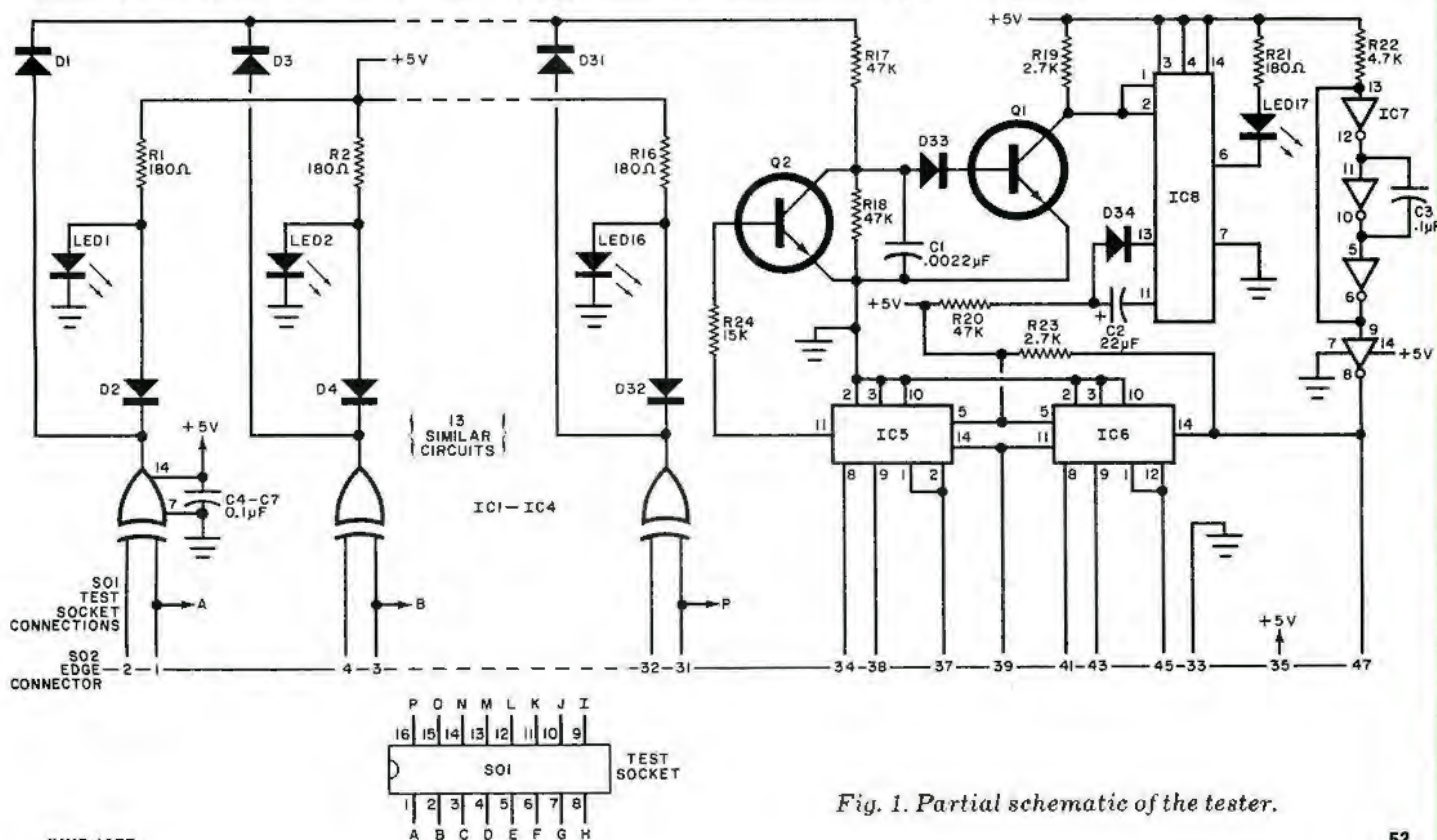


Fig. 1. Partial schematic of the tester.



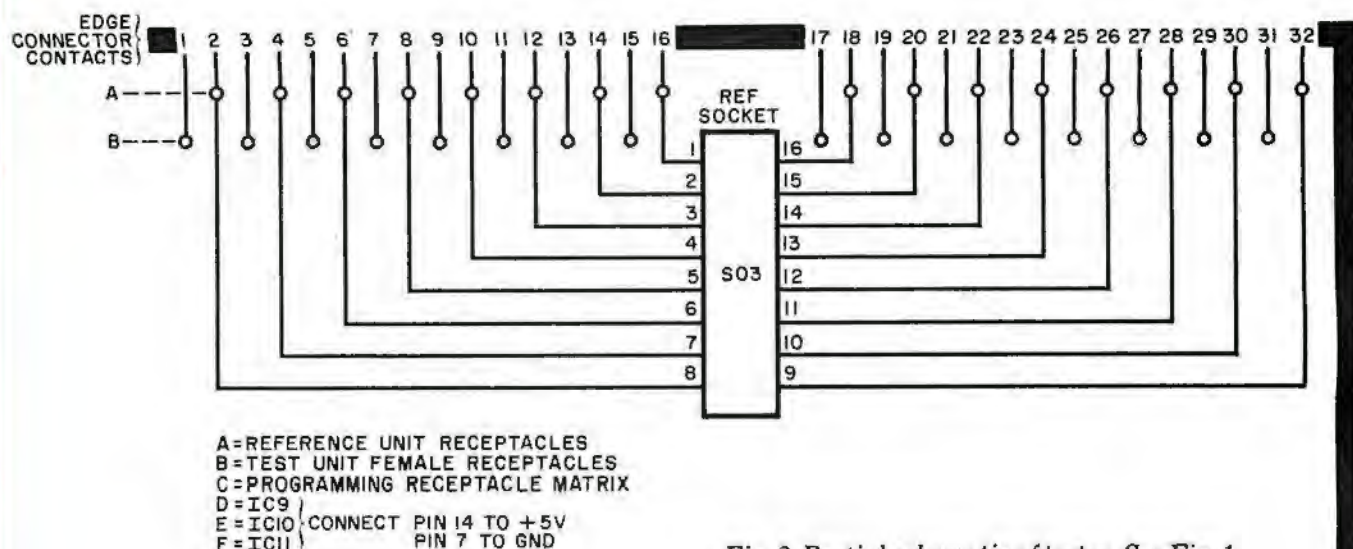
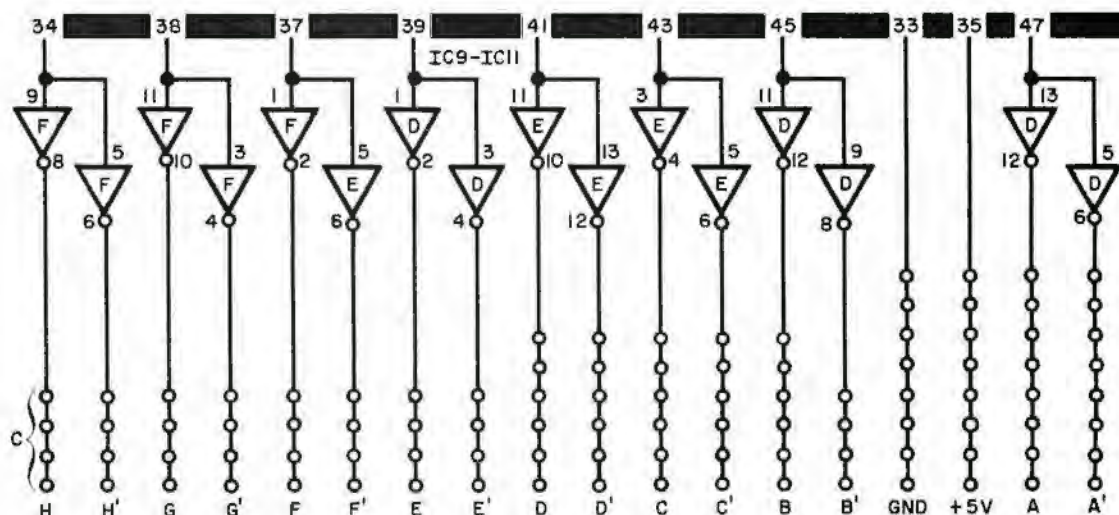


Fig. 2. Partial schematic of tester. See Fig. 1.



**About the Circuit.** The tester puts both IC's through their paces in parallel, covering all possible input combinations. The logic state at each input and output

pin is continuously monitored and compared to the reference IC. If there is a discrepancy with any input combination, the IC under test is defective and a fault

will be indicated by the IC tester.

The schematic diagram of the IC tester is shown in Figs. 1 and 2. The basic element for the electronic comparison is the exclusive-OR gate. Four two-input, exclusive-OR gates are contained in each SN7486 package (IC1 through IC4), for a total of 16 gates. One input of each gate is hardwired to the test IC socket (SO1) for individual pin monitoring. The other gate input is hardwired through programming-board edge connector SO2 to the corresponding pin on the programming board's reference IC

## PARTS LIST

C1—0.0022- $\mu$ F disc ceramic capacitor  
C2—22- $\mu$ F, 10-V tantalum capacitor  
C3 through C7—0.1- $\mu$ F disc ceramic capacitor  
C8—3000- $\mu$ F, 25-V electrolytic capacitor  
C9—10- $\mu$ F, 10-V tantalum capacitor  
D1 through D34—1N914 switching diode  
D35, D36—1N4001 rectifier diode  
IC1 through IC4—SN7486 quad 2-input exclusive-OR gate  
IC5, IC6—SN7493 4-bit binary counter  
IC7—SN7405 open collector hex inverter (do not substitute)  
IC8—SN74122 retriggerable monostable multivibrator  
IC9 through IC11—SN7404 hex inverter  
IC12—LM309K 5-volt regulator  
LED1 through LED17—Light emitting diode (TIL-32 or similar)  
Q1, Q2—2N3904 npn silicon transistor  
The following are 5% tolerance, 1/4-watt carbon composition resistors:

R1 through R16, R21—180 ohms  
R17, R18, R20—47,000 ohms  
R19, R23—2700 ohms  
R22—4700 ohms  
R24—15,000 ohms  
SO1—Zero-insertion-force 16-pin DIP IC socket (Textool No. 216-330M or equivalent)  
SO2—48-pin edge connector (Amphenol No. 2-583660-3 or equivalent)  
SO3—16-pin DIP IC socket  
T1—20-volt center-tapped, 1-ampere transformer (Burstn-Applebee No. 18A 1626-1 or equivalent)  
Misc.—Suitable enclosure (Harry Davies No. 260K with No. 261 cover, or equivalent), printed circuit boards, No. 4  $\times$  1/4" standoffs, suitable programming receptacles and patch cords, heat sink, thermal silicone compound, machine hardware, hook-up wire, solder, etc.  
Note: See Fig. 4 for information on ordering pc boards.

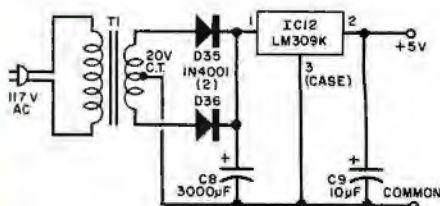


Fig. 3. Schematic for a suitable power supply.



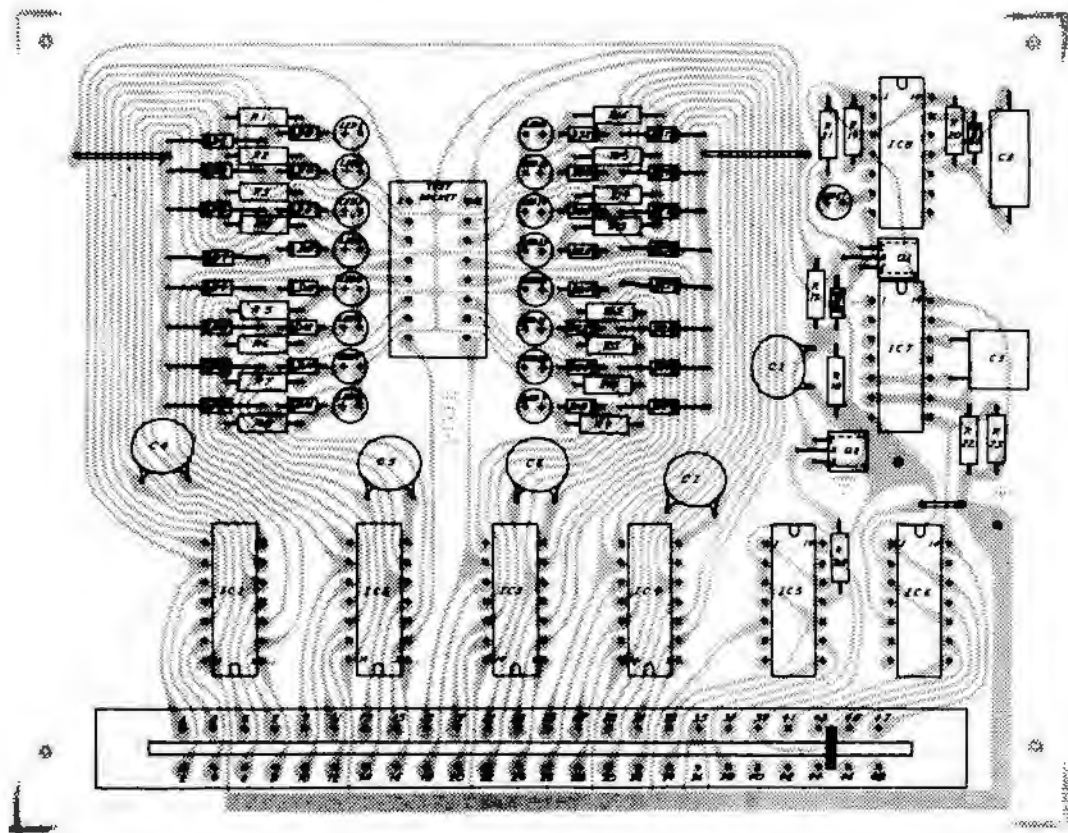
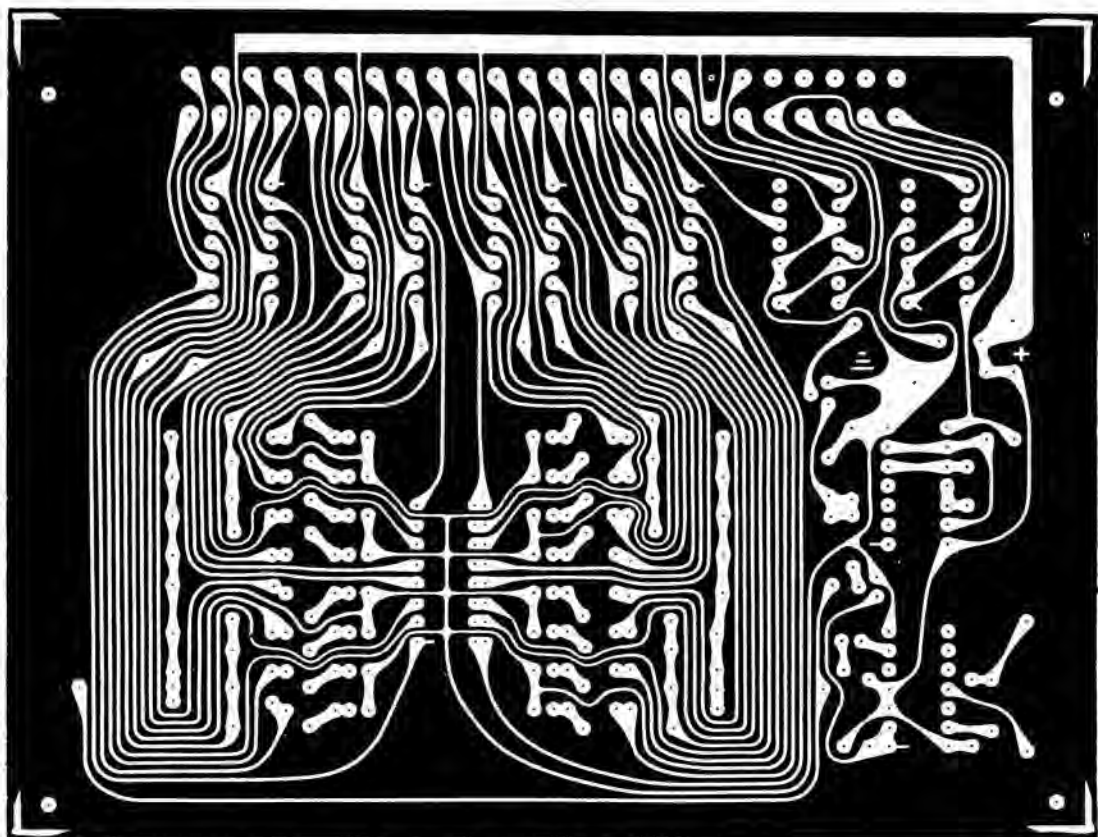


Fig. 4. Etching and drilling guide (right) and component layout (above) for main pc board. Note: etched and drilled pc boards for this and Fig. 5 are available from Select Circuits, 1411 Lonsdale Rd, Columbus, OH 43227 for \$18.95 a pair.

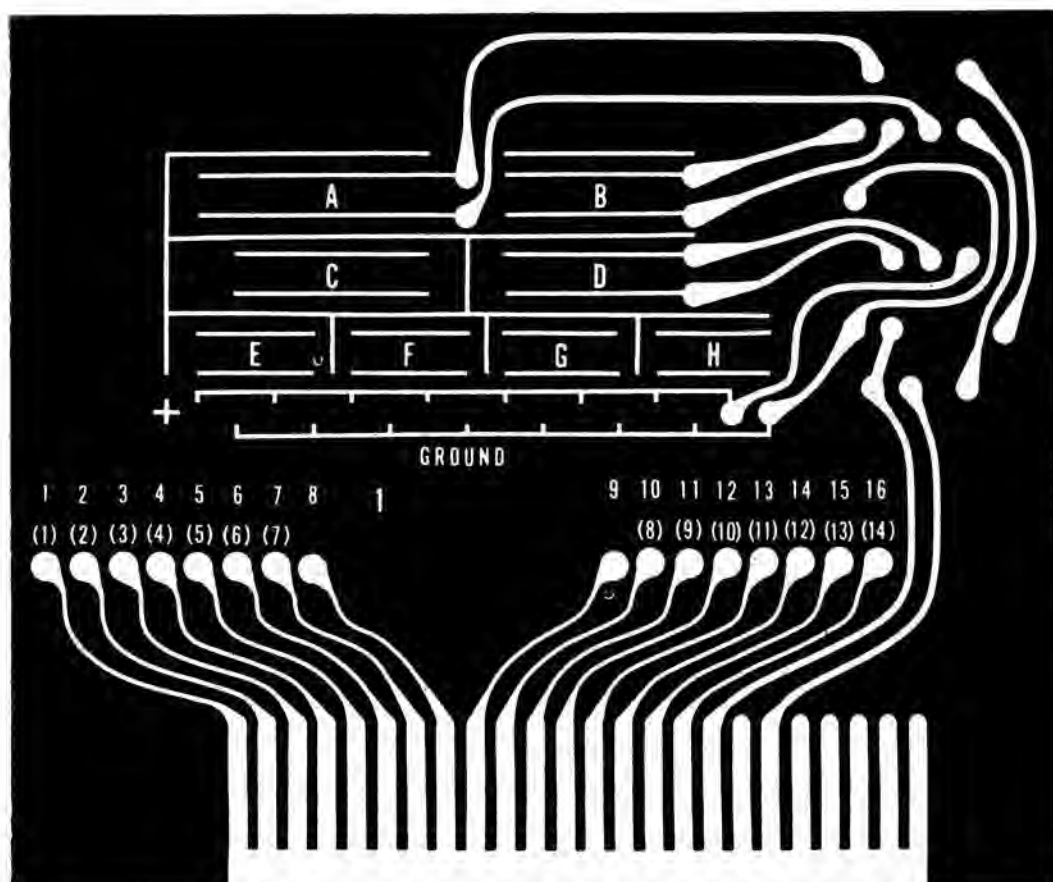


socket (SO3). Each exclusive-OR gate thus yields a logic-one output signal whenever its two input signals have different logic states. In other words, a logic one appears at the output of each gate when a discrepancy of performance between the test and reference IC's is detected.

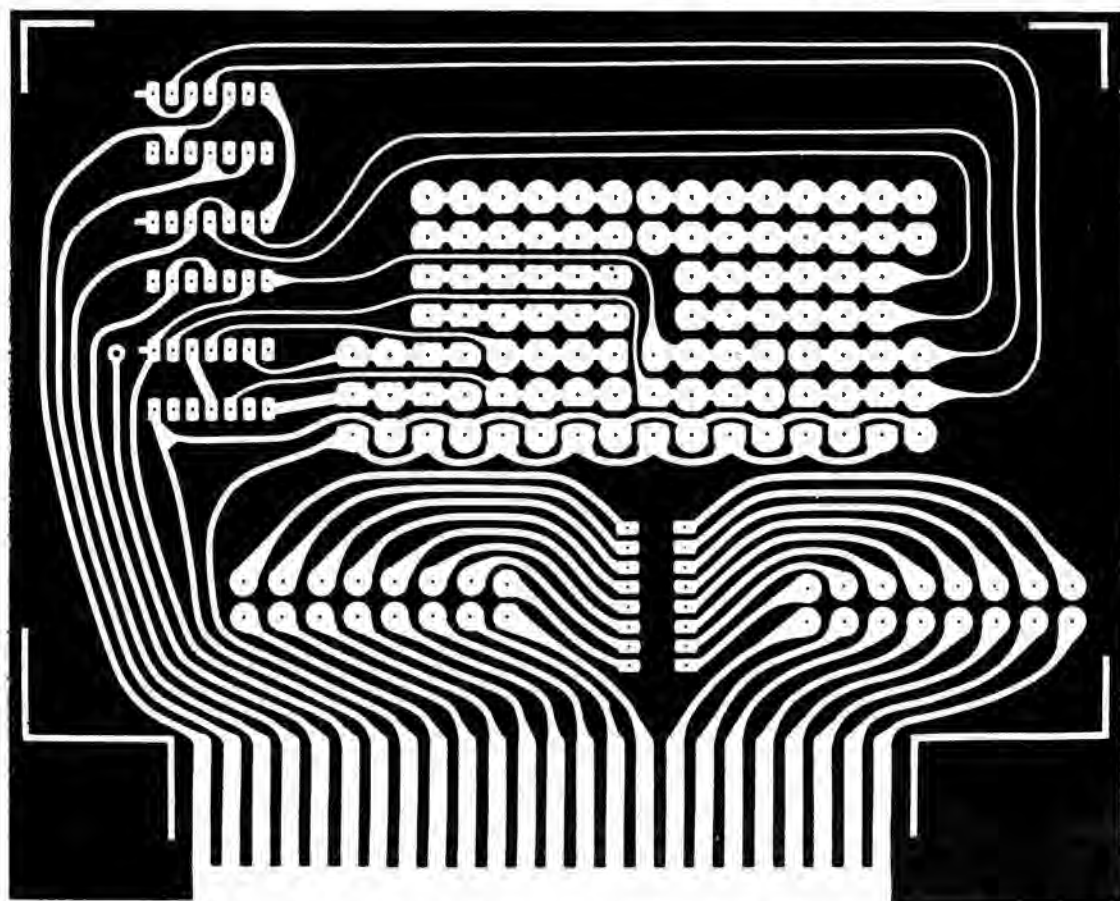
Two fault indicator circuits are employed. A LED (LED1 through LED16) at the output of each exclusive-OR gate glows when an error at the corresponding test IC pin is detected. Additionally, a master fault indicator (LED17) glows when one or more exclusive-OR gate output is high. Diodes D1, D3, D5, . . .

D31 are connected to R17 and to the exclusive-OR outputs to form one large OR gate. A pulse stretcher is included in the master fault indicator circuit to insure that LED17 will glow at full brilliance no matter what the duty cycle of the fault signal is. This is very important because it's possible for a fault signal to have a





*Fig. 5. Etching and drilling guides for both sides of the programming pc board. See Fig. 4 for ordering information.*



duty cycle as low as 0.4%. It would be difficult, if it were even possible, to detect light output from a LED driven by such a signal. The circuit also includes a low-pass filter (*R17*, *R18* and *C1*) at the

master fault input to reject noise spikes which might otherwise generate a deceptive fault indication.

The diode OR gate drives pulse stretcher *IC8* (an SN74122 monostable

multivibrator) and its associated components (*C2*, *D34*, and *R20*) through input conditioners *D33* and *Q1*. Because a continuous fault indication at the pulse stretcher input would trigger the one



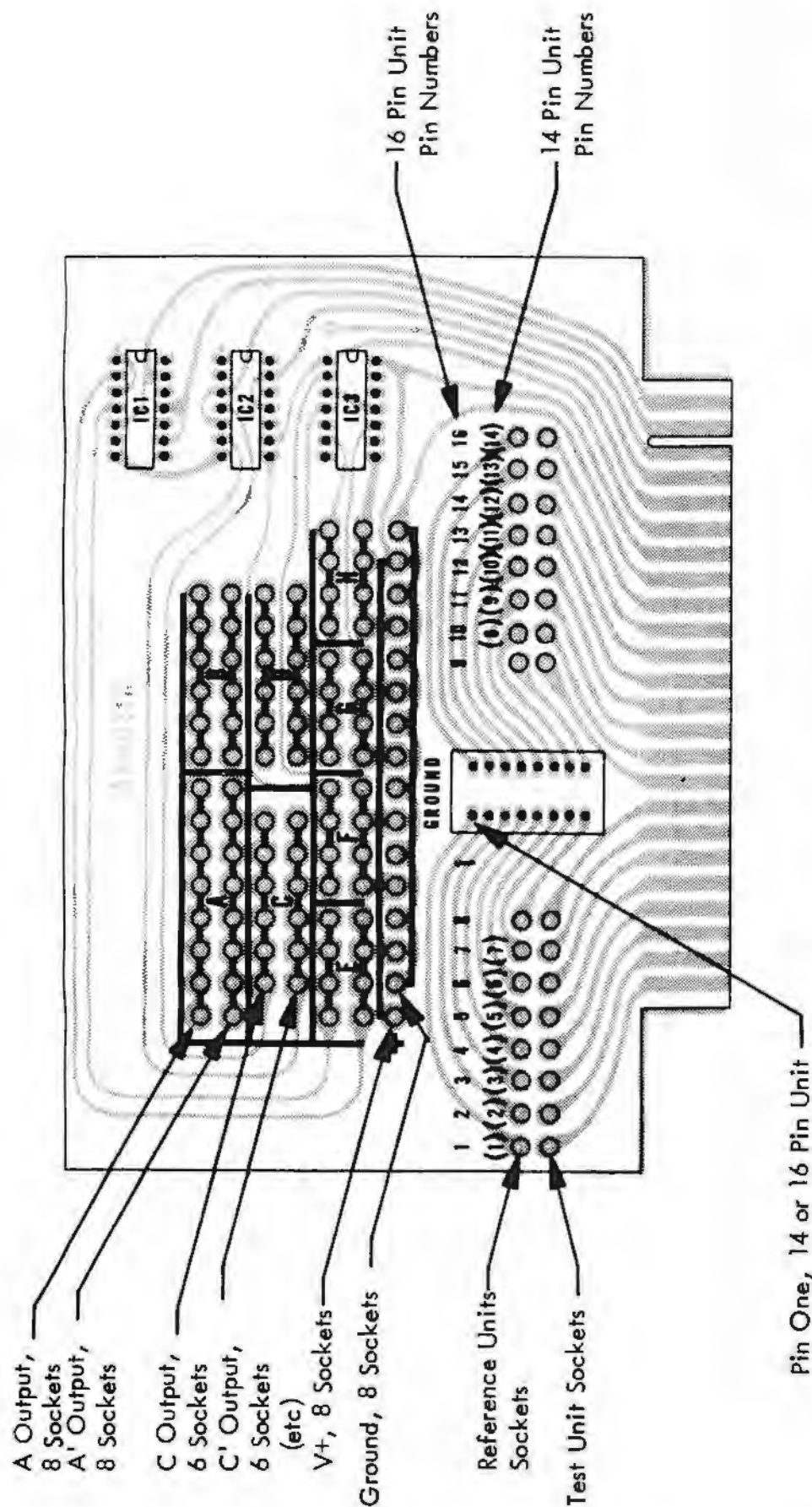


Fig. 6. Component placement guide for programming pc board.

shot for but one test cycle, the input must be periodically reset. This is accomplished by transistor Q2, which is driven by the last stage of a binary code generator.

To provide all possible test input combinations, an eight-stage binary code generator (IC5 and IC6, SN7493 4-bit counters) is incorporated. It is driven by a free-running square-wave generator consisting of C3, R22, and IC7, an SN7405 hex inverter. The square-wave generator provides a clock signal at about 5000 Hz. The clock output and the outputs from the first seven stages of the binary code generator are available at edge connector SO2. Thus there are eight independent test input signals present on the programming board. The eighth stage of the binary code generator is used to reset the master fault indicator, as mentioned earlier.

The programming board interfaces with the main tester board via 48-pin edge connector SO2. This allows pre-wired program cards to be kept on hand and simply plugged into the tester for quick checks of common IC's. Each bit of the binary code is independently buffered by sections of IC9 through IC11 (SN7404 hex inverters) to drive both the reference and test IC inputs. Separate buffering for all inputs of each IC ensures that such logic-overriding faults as input short circuits will be detectable.

The tester is powered by a simple 5-volt, 1-ampere regulated supply (Fig. 3). Ac from T1 is converted to pulsating dc by a full-wave rectifier (D35 and D36) and filtered by C8. Unregulated dc is then applied to IC12, an LM309K 5-volt regulator, which is essentially blow-out proof. Current limiting is built in to the IC, as is thermal shutdown. Output bypass capacitor C9 provides increased stability and improved transient response.

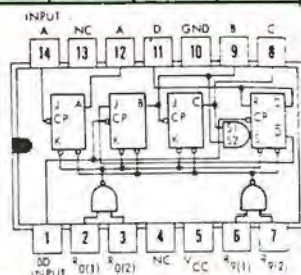
However, other power supply configurations can be used. For example, T1 could be a 12.6-volt, 2-ampere transformer driving a bridge rectifier. The output of the bridge would then be filtered and regulated as in Fig. 3.

**Construction.** Assembly of the tester is not critical. However, the use of pc boards will simplify the task. Etching and drilling guides for the main and programming boards are shown in Figs. 4, 5, and 6. The main pc board contains most tester components mounted in a conventional manner. It in turn is mounted on four 1/4-inch (6.4-mm) No. 4 standoffs behind the front panel of a molded plastic box. Holes are cut in the front panel for the test socket, the sixteen indicator



Reference Unit Connection	A'	NC	NC	NC	COM	NC	NC	X
Test Unit Connection	A	NC	NC	NC	COM	NC	NC	X
Pin Number	(14) 16	(13) 15	(12) 14	(11) 13	(10) 12	(9) 11	(8) 10	X

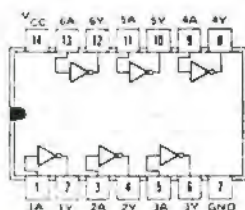
DEVICE TYPE: CIRCUIT TYPES SN5490, SN7490  
DECADE COUNTERS



Pin Number	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	X
Test Unit Connection	B	C	D	NC	V+	E	F	X
Reference Unit Connection	B'	C'	D'	NC	V+	E'	F'	X

Reference Unit Connection	V+	B'	NC	B'	NC	B'	NC	X
Test Unit Connection	V+	B	NC	B	NC	B	NC	X
Pin Number	(14) 16	(13) 15	(12) 14	(11) 13	(10) 12	(9) 11	(8) 10	X

DEVICE TYPE: CIRCUIT TYPES SN5404, SN7404  
HEX INVERTERS



Pin Number	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	X
Test Unit Connection	A	NC	A	NC	A	NC	COM	X
Reference Unit Connection	A'	NC	A'	NC	A'	NC	COM	X

NOTES: All inputs could have been tied in parallel to A & A' for example, but it is not necessary to do so.

Fig. 7. Sample programming sheets for testing decade counters (above) and hex inverters (below).

LED's, the master fault indicator and the edge connector.

Before mounting any components on the main board, use it as a template to

locate holes and cutouts on the front panel. It can be clamped to the front panel and used as a drilling guide for the four standoff mounting holes. The loca-

tions of the master fault indicator, the test socket, and edge connector can be specified by marking the corners of each cutout. Components which do not protrude through the front panel must be mounted flush to the main pc board so that they will not interfere with the fit of the board to the front panel. If LED's with base diameters larger than 0.200" (5.08 mm) are used for the sixteen fault indicators, their bases must be filed so that a proper fit is obtained. The author recommends the use of a 16-pin zero-insertion-force (Textool No. 216-330M or equivalent) IC socket for the test IC location. A conventional DIP socket can be substituted, of course, but is much less convenient to use for many IC's.

The programming board is double-sided. Because most builders will not be able to produce plated-through holes, IC and socket pins, as well as programming receptacles must be soldered (where applicable) to both sides of the board. The programming receptacles and jumpers (patch cords) are a matter of preference. The solder pads on the pc board are large enough to accept eyelet sockets for the 0.040" (0.916-mm) pin terminated type of patch cords. The most economical programming patch cord is simply a length of No. 22 or 24 solid insulated hookup wire. The wire should be cut to the desired length and about 1/2" (1.27 cm) of insulation stripped from each end. If diagonal cutters are used to trim wire length, position the cutters so that their hollow side faces the body of the jumper when the wire is clipped. Then a point will be formed on the wire, making it easier to insert the jumper into a programming receptacle.

A solid wire jumper is best accommodated by a 0.020" (0.458-mm) receptacle. No. 24 wire is approximately 0.020" (0.458 mm) in diameter and fits such a receptacle exactly. No. 22 wire is about 0.005" (0.127 mm) larger in diameter and thus makes a more secure fit in some 0.020" (0.458-mm) receptacles. Probably the most inexpensive 0.020" (0.458-mm) receptacle available is the Molex Soldercon, which is sold in quantity by many dealers in the Electronics Marketplace in this magazine.

You might want to solder wire jumpers to appropriate points without using any receptacles at all. This can be done if you desire a permanent testing board for a specific IC type. You could even make one "deluxe" programming board with patch cords and receptacles for testing any TTL IC, and at the same time fabricate a number of prewired boards set up for frequently tested IC types.



Power supply construction is not critical. Point-to-point wiring is adequate. Connections from the IC tester to the power supply should be made directly at the voltage regulator's terminals. If the project is mounted in a plastic, rather than aluminum, enclosure, a heat sink must be provided for IC12. In any event, heat sink compound such as Dow Corning No. 340 silicone heat-sink compound should be used when mounting the IC on a heat dissipating surface.

Worst-case maximum power dissipation for the regulator will be approximately (in watts) the unregulated supply voltage minus five volts, because maximum current is about one ampere. The maximum dissipation of the regulator must be kept in mind when selecting the power supply transformer and heat sink. The rectified voltage across the filter capacitor will be about 1.4 times the rms voltage from the center tap to one end of the secondary in a full-wave circuit. If a bridge rectifier is used, the dc voltage across the filter capacitor will be about 1.4 times the rms voltage across the entire secondary winding (no center tap is needed). In any event, the unregulated dc applied to the input of IC12 should never drop below 8 volts at full load. Otherwise the output will not be regulated. Also, the input to the regulator must not exceed 35 volts or the integrated circuit will be damaged.

**Programming.** All that's required to program the tester is patching input signals to the reference and test IC's. Each individual input of the test IC should be connected to a different binary code bit (A through H). In multiple section IC's, corresponding inputs can be wired in parallel. For example, when programming a test of a quad two-input NAND IC (SN7400), one input of each gate can be connected to the A output of the binary code generator and the other input of each gate to the B output. Thus there would be four gates with their inputs wired in parallel to the A and B bits.

When specific binary code generator outputs (A through H) are patched to the test IC inputs, the corresponding separately buffered outputs A' through H' must be patched to the corresponding reference IC inputs. Programming is completed by patching +5 volts and grounds to the appropriate pins of both IC's.

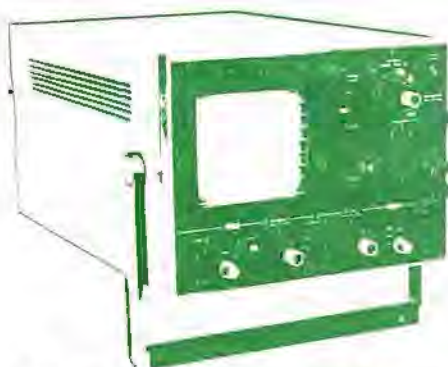
The foil on the component side of the programming board is etched to provide clear labelling. Binary code generator outputs are boxed in and identified by the letters A through H. Separately buffered outputs are shown bussed together on the component side. This bussing is done for appearance's sake only and the programming receptacles need not be soldered on this side of the board. Actual bussing is done on the other side.

Note, however, that the right-most receptacles in areas A, B and D must be soldered on both sides of the pc board.

The choice of which binary code outputs are used to drive either the reference IC or test IC inputs is unimportant so long as only one set (A through H or A' through H') is used with one of the two IC's. The +5 volt supply is identified by a "+" and is shown bussed on the component side of the board. Similarly, the ground is so labelled and bussed. Again, this bussing on the component side of the board is for appearance only and the receptacles need not be soldered on the component side. But the right-most receptacles must be soldered on both sides of the board for proper connection to the power supply.

Receptacles tied to the test and reference IC sockets parallel each other along the edge of the board just above the edge connector contacts. They are labelled with pin numbers for 14- (in parenthesis) and 16-pin DIP's.

Two programming examples are shown in Fig. 7. It is desirable to make up similar programming sheets for each IC you test. Then you can use them as check-off sheets to verify proper programming and as a permanent record of the test program. Similar tests can then be performed at a future date by quickly referring to the appropriate programming sheet. ♦



## GUIDE TO OSCILLOSCOPES

*How to weigh the functions and performance that you need for your application in choosing this instrument.*

BY CLAYTON HALLMARK

**E**VERYONE who gets into electronics, either vocationally or as a hobby, hopes to own an oscilloscope. This isn't surprising, considering that the scope is one of the most versatile test instruments ever to become available. Not only can an oscilloscope display a "picture" of the actual signal in a circuit under test, it can also measure the signal's amplitude, frequency, and time period.

The oscilloscope represents a sizable investment, but it is worth every penny you invest if you buy what you need and use it wisely. Here are some basic scope guidelines you should know be-

fore buying the instrument, including operating principles and specifications.

**Curves and Measurements.** The oscilloscope's usefulness in measuring time and voltage is illustrated in Fig. 1. Horizontal distances on the screen represent time by a fixed amount per graticule square, while vertical distances represent voltage, also by a fixed amount per square.

A TIME/DIV (typical) control on the scope can be used to set the width of the displayed image. The calibration markings on this control permit the elapsed

time between any two points on the display to be determined by multiplying the horizontal spacing in divisions by the numerical value of the TIME/DIV control setting. For example, the horizontal division between points A and B in Fig. 1 is five divisions. If the TIME/DIV setting is 100  $\mu$ s/division, the elapsed time between A and B is  $100 \mu$ s  $\times$  5 = 500  $\mu$ s.

The VOLTS/DIV (typical) control on the scope is used to set the height of the display. The vertical distance tells the magnitude of the voltage of the displayed waveform in much the same manner as the horizontal distance tells the time be-



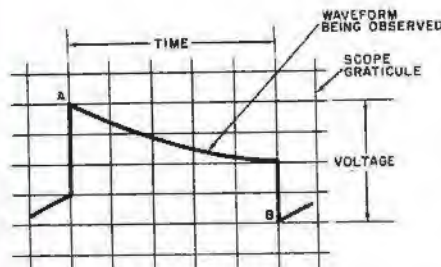


Fig. 1. Displayed waveform is plot of voltage versus time.

tween any two points. The voltage (vertical) difference between points A and B in Fig. 1, therefore, is four divisions. Now, if the VOLTS/DIV control is set to 0.5 volts/division, the voltage difference is  $0.5 \times 4 = 2$  volts.

**Basic Scope.** A simplified diagram of an oscilloscope is shown in Fig. 2. Electron beam deflection is accomplished by controlling the charges on two sets of deflection plates within the CRT. One pair is for vertical deflection, and the other

another sweep. During this retrace interval, special circuits within the scope "blank" the electron beam so that it is not visible on the CRT screen.

During the relatively slow left-to-right progression of the electron beam on the CRT screen, whatever signal is applied to the vertical input is amplified and causes the CRT electron beam to be deflected up and down in step with the input signal. If the input signal is a steady dc voltage, the display is a straight line as shown in Fig. 3A. If one cycle of a sine wave, whose time interval is exactly the same as the sweep time interval, is used as the vertical input to the scope, the resultant CRT display will be a single sine wave (Fig. 3B). And, if the input sine wave time interval is only half of the sweep time, then two cycles of the input waveform will be seen on the CRT screen as shown in Fig. 3C.

Older, and inexpensive present-day scopes, have a SWEEP FREQUENCY control that permits the horizontal frequency to be adjusted to an exact submultiple of

a pulse to the sweep generator, which then produces one cycle of sweep. The sweep generator then "rests" until the input is again at the selected polarity and amplitude. If the input is a continuous sine wave, a continuous sawtooth is generated, as in a recurrent-sweep scope, but in sync with the input signal so that the display "stands still". If there is no input signal, no sweep occurs. Triggered-sweep scopes can be set so that they do not produce a trace in the absence of a vertical signal. Also, if the input consists of random pulses, the sweeps occur only when there are pulses.

Because triggered-sweep scopes use an extremely linear (with time) ramp, they provide an accurate way of measuring the time between events on a waveform. These scopes are thus said to use a "time base" instead of a horizontal oscillator. The time base's control is calibrated in *time/division* instead of *frequency*. In addition, the triggered-sweep scope provides a means for measuring small portions of pulse trains, random events, single events, and signals of rapidly changing frequency.

Recurrent-sweep scopes are far from extinct and certainly have their place today, especially where instrument cost

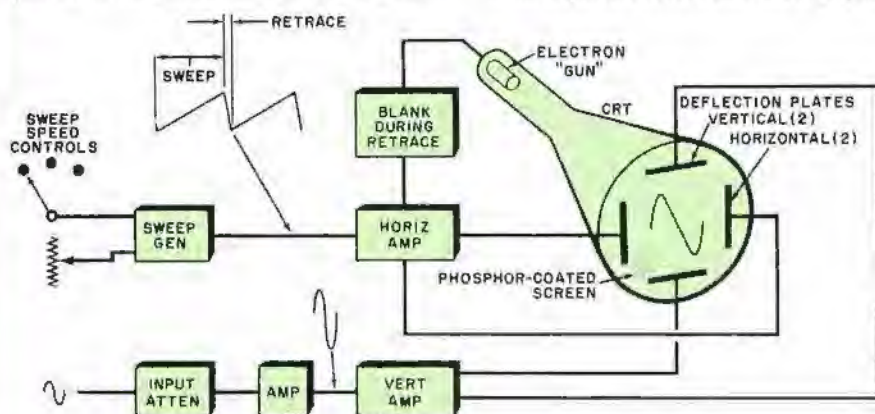


Fig. 2. Simplified diagram of how an oscilloscope works. Two sets of plates deflect the electron beam.

er pair, mounted at right angles to the vertical plates, is for horizontal deflection of the beam.

The horizontal sweep generator supplies a sawtooth waveform that is voltage amplified and applied to the two horizontal deflection plates. The amplified sawtooth waveform then forces the CRT electron beam to move at a uniform rate across the CRT phosphor-coated screen. The action of the electron beam impinging on the phosphor causes a dot of light to appear on the CRT, thus the horizontal sweep produces a line of light across the screen, which moves in a left-to-right direction.

When the sweep sawtooth reaches the "retrace" portion, it causes the electron beam to "snap" back to its origin (the left side) and await the start of

the vertical frequency. If this is not done, and if the starts of successive sweep ramps occur at different points on the input signal (positive peak, negative peak, start of positive alternation, etc.), the jumbled pattern shown in Fig. 4 results. In these "recurrent-sweep" scopes, the sweep signal voltage is generated by a sawtooth oscillator that is usually synchronized to the input signal by feeding it a sample of the input signal from the vertical circuits.

More modern and expensive oscilloscopes employ "triggered-sweep" instead of recurrent-sweep design (Fig. 5). The sweep generator is inactive until a trigger signal, derived from the input signal, starts it operating. When the input signal reaches the selected polarity and amplitude, the trigger circuit delivers

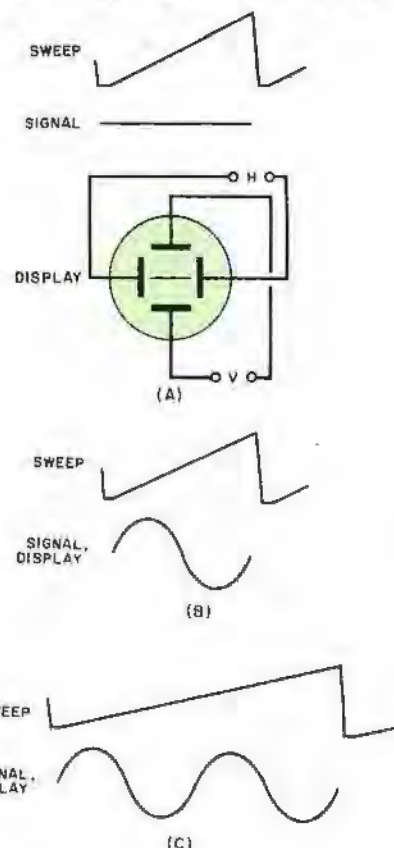


Fig. 3. Display depends on horizontal input and sweep.



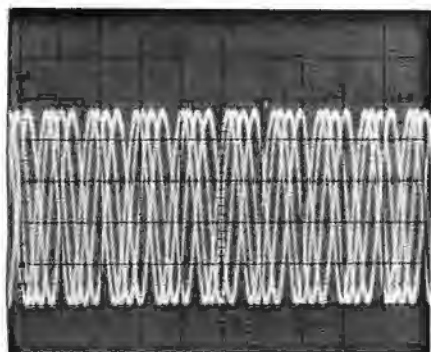


Fig. 4. Out-of-sync scope produces this meaningless pattern.

must be kept at a minimum. Aside from lower cost, the recurrent-sweep scope may be easier to use than the triggered-sweep scope. Some scopes even offer both types of sweep at the flip of a switch. (Providing both types of sweep are handy for establishing the baseline in the absence of an input signal.)

**Two Scopes in One.** Sometimes we are interested in measuring the time between events on two different signal paths. This can be done with a time-base (triggered-sweep) oscilloscope if there is a way of simultaneously displaying the two wave-forms. Many modern triggered-sweep scopes, therefore, have dual-trace capability to fill this need. With such a scope, the input and output waveforms (for example) of a circuit can be viewed at the same time and compared for time (phase) differences, distortion, and other differences.

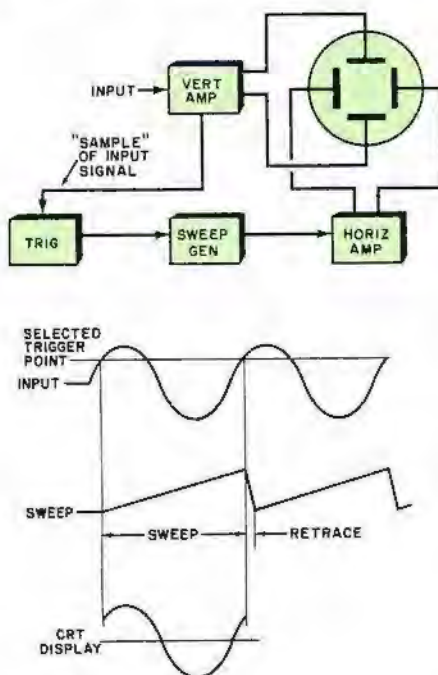


Fig. 5. Triggered-sweep scope and waveforms involved.

A dual-trace scope has two independent input channels that are fully controllable independently of each other, and whose electrical characteristics are carefully matched. The two signals are fed to the vertical-deflection plates via an electronic switch (Fig. 6).

The vertical amplifier circuit can be switched between the two channels in either of two ways. With the scope in its alternate mode, as in Fig. 6, switching occurs during sweep retrace; sweep one displays signal A, sweep two signal B, sweep three signal A, etc. The persistence of the CRT screen phosphor leaves an afterglow when a given trace is not being drawn causing the waveform to linger on the screen during alternate sweeps. Consequently, both waveforms appear to be displayed simultaneously. However, if the sweep rate is set sufficiently slow, as for viewing low-frequency signals, one waveform may begin to fade while the other is being

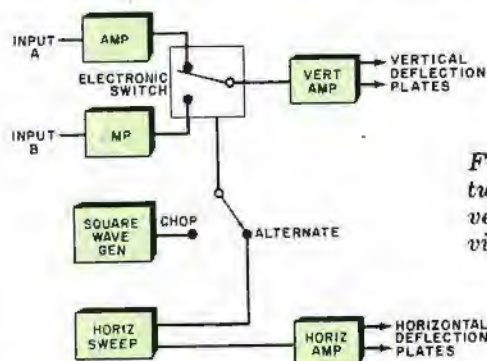


Fig. 6. In dual-trace scope, two signals are fed to vertical-deflection plates, via an electronic switch.

traced on the CRT screen, and the display will flicker. This calls for the "chop" mode of operation.

In the chop mode, a relatively high-speed square-wave oscillator alternates the electronic switch rapidly during sweeps. This produces a display such as that shown in Fig. 7. In practice, the traces are made up of so many segments that the integrating mechanism of the eye makes each appear as a continuous waveform.

Front-panel switches on dual-trace oscilloscopes permit selection of either the alternate or chop modes as desired. In a few scopes, the mode automatically changes from chop to alternate when a sweep speed of 1 ms/cm or slower is selected. This prevents flickering and speeds setup time when using the scope.

Some dual-trace scopes have a switch for exchanging the horizontal amplifier for one of the vertical amplifiers. In this XY mode of operation, the matched vertical amplifiers are used for both ver-

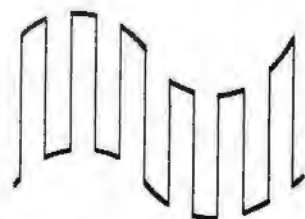


Fig. 7. Display with electronic switch in chop-mode operation.

tical (channel-A) and horizontal (channel-B) input signals. A plot of the Channel-A signal versus the channel-B signal results. One signal is plotted on the X (horizontal) axis, while the other is plotted on the Y (vertical) axis. Both signals are treated in the same manner by the amplifiers, and both can be measured in volts per centimeter (V/cm) by using the calibration controls.

A phase-relationship (or Lissajous) pattern appears on the screen when the scope is used in the XY, or "vector-

scope," mode. One of the simplest loops to be obtained in this mode is shown in Fig. 8. The slant of the loop reveals the phase relationship of the signals. This mode can also produce a more complex loop, which looks like a "daisy" (Fig. 9), for checking the chroma circuits in a color-TV receiver. (A special CRT graticule is used with the daisy pattern to provide accurate color-TV receiver vectorscope

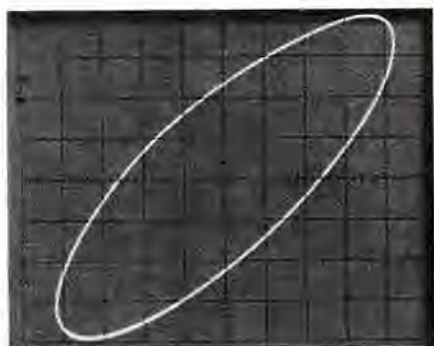


Fig. 8. Lissajous figures are used for phase measurements.



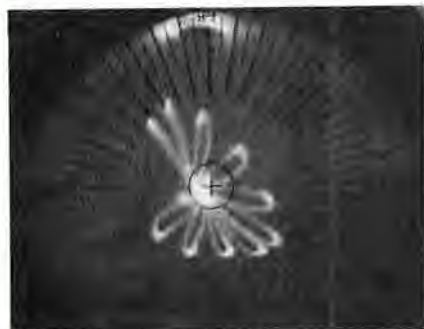


Fig. 9. Vectorscope pattern is useful in checking color TV.

operation.) Such a scope configuration can also "draw" the load line of a power supply or transistor.

**Looking at Specifications.** As with all electronic gear, and particularly electronic test equipment, it is important that you understand the various technical specifications used for oscilloscopes. Let us, therefore, list the various tech specs of a scope and explain what each means.

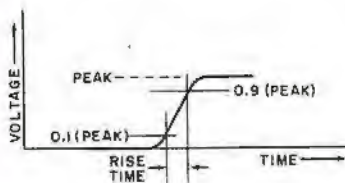


Fig. 10. Diagram shows how risetime of a wave is defined.

**Frequency Response.** The 3-dB-down frequency response, or bandwidth, of the vertical channel is the most important factor in the price and applicability of a given oscilloscope. The usable response of a scope just for radio work might not have to be greater than the audio range, but a TV repairman might need a scope that can display signals from 30 Hz to beyond 4 MHz. For more exhaustive and demanding tests,

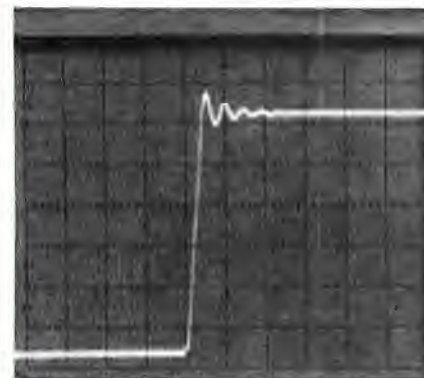


Fig. 11. Excessive overshoot caused by scope's poor response.

scopes with responses out to 10, 15, 50, or even 100 MHz might be required. Needless to say, you should select a scope according to the type of work you expect to be performing. You would not, for example, select a scope with a 100,000-Hz (100-kHz) range to do servicing on color-TV receivers. Conversely, a 100-MHz scope's range would be wasted if all you plan to work on is audio circuits.

**Risetime.** Those of us who do a lot of work on digital circuits are particularly interested in the risetime of a scope. As illustrated in Fig. 10, the risetime of a pulse is the time it takes for the leading edge of a square wave to rise from 10% to 90% of its peak value. If, for example, it is necessary to measure within 3% a waveform risetime known to be in the 0.04- $\mu$ s range, an oscilloscope with a risetime of not more than 0.01  $\mu$ s would be required.

When comparing oscilloscopes, it is sometimes necessary to convert a specification from one form to another to determine how each scope measures up. If the bandwidth (BW) is known and you wish to know the risetime ( $t_r$ ), or vice versa, just divide the known quantity into 0.35. The general formula is  $BW \times t_r = 0.35$ . Bear in mind, however, that this formula works only if the response of the scope rolls off smoothly, until it is close to 12 dB down at twice the -3-dB frequency. If the scope does not follow this Gaussian curve, excessive overshoot (more than 2% or 3%) occurs as shown in Fig. 11. If the scope does have a Gaussian response, it may be usable at frequencies up to twice the rated limit.

**Deflection Factor.** This is a measure of the oscilloscope's sensitivity or ability to display low-level signals. It indicates the signal amplitude required to cause the trace beam to be deflected one graticule division. The deflection factor is commonly given in millivolts peak-to-peak per division (mV p-p/div.). For some scopes, 10 mV/cm is common. Again, in comparing scopes, their specifications must be converted to a common term. If the voltage is given in rms, multiply by 2.828 to obtain peak-to-peak; if the division is 1", divide by 2.54 to obtain the centimeter equivalent.

Most modern scopes have adequate sensitivity. However, remember that, in comparing scopes, the lower the deflection factor, the easier it is to display low-level signals.

**Accuracy.** This is really calibration accuracy. It is comparable in meaning and percentage to the accuracy of an analog meter. Accuracy is generally in the

range of 3% to 5%. The accuracy of the vertical calibration tells how closely the input voltage level can be measured, while the horizontal accuracy refers to the time (and frequency) measurements.

## OSCILLOSCOPE MANUFACTURERS

**B&K Precision, Dynascan Corp.**  
6460 W. Cortland Ave.  
Chicago, IL 60635

**Ballantine Laboratories, Inc.**  
Box 97  
Boonton, NJ 07005

**Dumont Oscilloscope Laboratories, Inc.**  
40 Fairfield Pl.  
W. Caldwell, NJ 07006

**Elco Electronic Instrument Co., Inc.**  
282 Malta St.  
Brooklyn, NY 11207

**Heath Company**  
Benton Harbor, MI 49022

**Hewlett-Packard Co.**  
1501 Page Mill Rd.  
Palo Alto, CA 94304

**Hickok Electrical Instruments**  
10514 Dupont Ave.  
Cleveland, OH 44108

**Leader Instrument Corp.**  
151 Dupont St.  
Plainview, NY 11603

**Lectrotech Inc.**  
5810 N. Western Ave.  
Chicago, IL 60659

**Phillips Test and Measuring Inst. Inc.**  
400 Crossways Park Dr.  
Woodbury, NY 11797

**Sencore Inc.**  
3200 Sencore Dr.  
Sioux Falls, SD 57107

**Systems Electronics, Inc.**  
9727 Inglewood Ave.  
Inglewood, CA 90301

**Tequipment Div. of Tektronix**  
Box 500  
Beaverton, OR 97005

**VIZ Manufacturing Co.**  
335 E. Price St.  
Philadelphia, PA 19144

**Vu-Data Corp.**  
7170 Convey Ct.  
San Diego, CA 92111



**Impedance.** The input impedance of an oscilloscope is usually a 1-megohm resistance shunted by a 30-pF capacitance. (Most laboratory-grade scopes have 50-ohm input impedances.) The input impedance with a probe is typically 1 megohm shunted by 20 pF for a low-capacitance probe. To prevent circuit loading, a low-capacitance probe is desirable. Some scopes have switch-selectable input impedance: 1 megohm for general use with a probe and 50 ohms for pulse and CW measurements in low-impedance circuits.

Most oscilloscopes can tolerate up to 500 volts peak-to-peak at their inputs without suffering damage. However, if you plan to be working with higher voltages, we strongly suggest that you invest in a 5-kV or higher probe. The maximum voltage that can be measured by an oscilloscope depends on the instrument's voltage rating, availability of a high-voltage probe, and the scope's maximum deflection factor.

**Sweep Rate.** The number of cycles in a display is equal to the signal frequency divided by the sweep rate. If you link up a wideband vertical amplifier and a low-performance sweep generator, the waveform displayed will be highly distorted.

For best results, you want no more than about six cycles of signal displayed. Hence, for TV work, you need a sweep speed of at least 500 kHz, which would yield about seven cycles of the 3.58-MHz color oscillator signal. A sweep of only 100 kHz would put no less than 35 cycles on the CRT screen.

To determine how many cycles of a given frequency a triggered-sweep scope will display at its fastest sweep rate, the time/division specification must be converted to frequency using the formula  $f = 1/(t/\text{div} \times W)$ , where  $t/\text{div}$  is the lowest sweep setting and  $W$  is the width of the screen. A sweep rate of 0.2  $\mu\text{s}/\text{cm}$  on a screen 10 cm wide corresponds to a 500-kHz sweep rate. For many scopes, the maximum sweep rate, rather than the bandwidth of the vertical amplifier, will determine the maximum high-frequency operating point.

**Sweep Magnifier.** This handy feature allows the display to be expanded, or magnified, vertically by operating a switch. Typical expansion factors are  $\times 2$ ,  $\times 5$ , and  $\times 10$ . Either or both ends of the trace then go off the screen, and the portion of the trace that is desired to be examined can be positioned on-screen. In effect, the sweep magnifier increases the maximum sweep rate of the scope. If a scope has a top sweep rate of 0.1  $\mu\text{s}/\text{cm}$ ,

with  $\times 5$  magnification, the top rate becomes 0.02  $\mu\text{s}/\text{cm}$ .

The sweep magnifier allows display of part of a pulse train that occurs much later than the triggering signal. It also allows complex signals to be spread out for close examination.

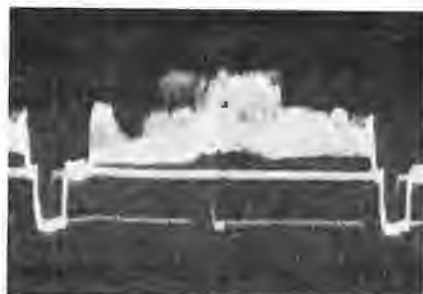


Fig. 12. Scope display having TVV and TVH modes of operation.

**TVV and TVH Modes.** Some time bases in oscilloscopes have two preset positions for TV vertical and TV horizontal waveforms. The positions, usually labelled tvv and tvh, correspond to the television vertical and horizontal sync rates of 60 Hz and 15.75 kHz (sometimes 7.875 kHz). With this feature, viewing the composite video signal (Fig. 12) is greatly simplified.

**Alternate vs. Direct Coupling.** In essence, a dc scope has a vertical amplifier system that will respond all the way down to the dc level, and thus display the input waveform exactly as "seen" by the scope input. In this mode, the scope can also be used as an accurate dc voltmeter.

An ac scope is simply one in which there is a blocking capacitor in the input circuit (and possibly elsewhere in the vertical amplifier system) so that the amplifier will not respond down to the dc level. Although a scope is used most often on ac signals, sometimes these signals are found "riding" on a dc level, as at the plates of vacuum-tube amplifiers, where the ac signal of interest can be as much as 250 volts dc above ground. Obviously, if this composite signal is fed to a dc scope, the trace will disappear off the screen, and it may be very difficult to bring into view. Therefore, an ac scope is handy when you have to examine signals that ride on some relatively high dc level.

Since an ac scope will not respond to dc signals, the reactance of the capacitor limits the lower-frequency response and that is why ac response is usually specified as from 1 or 2 Hz up. Ac coupling also means that steady-state dc signals, such as those forming the tops

and bottoms of square waves will have a "droop" that is not present on the original signal. It also means that ac scopes cannot be used as dc voltmeters. To get the most of both approaches, purchase a scope having both ac and dc coupling.

**Probes.** An oscilloscope is effective only when it can be interfaced with a circuit that requires waveform analysis, and this is where probes come in.

There are several types of probes, each designed for a specific purpose. They range from simple coaxial-cable types with test prods at the ends, through input impedance multipliers, to r-f probes that can be used to examine signals operating at many hundreds of megahertz.

The simplest probes are lengths of coaxial cable with one end terminated in a suitable scope input connector and the other end fitted with alligator or plastic encased test prods. The grounded braid of the cable reduces any noise pickup.

Input impedance multipliers are usually specified with a ratio—10:1, for example—which means that you can look at signals whose voltage levels may be greater than the maximum voltage sensitivity of the scope. It also means that the scope input impedance is raised by a similar factor. This can be important when making measurements in very high-input-impedance circuits (such as CMOS) to avoid loading problems.

The use of an r-f-demodulator probe does not extend the scope bandwidth to the probe limits (which may be 250 MHz). Such a probe can be used to demodulate a signal from an r-f carrier up to the probe limits. Using such a probe, the modulation of a CB, ham, or business radio can be easily examined for modulation characteristics, as long as the modulation frequency does not exceed the demodulation limits of the probe or the response of the scope.

**Summing Up.** An oscilloscope may be the most sophisticated instrument you ever buy. Choosing a particular one from the many makes and models on the market is not easy. The best advice to follow is to decide "how much" scope you need and how much money you are willing to invest. Then compare specifications. Give serious consideration to your needs. Vectorscope capability and TVV and TVH features would mean more to a TV service technician than an electronics hobbyist, for example. For serious experimenting, do consider dual-trace capability, triggered sweep, and sweep magnification. ◇





**Portable counter features six-digit LED display and 10-Hz to 100-Hz resolution.**

**O**WNING a frequency counter is no longer a luxury. For electronics experimenting and for servicing today's equipment, one needs this piece of test gear to count clock rates, adjust oscillators, and so on. Here's a handy, low-cost, portable counter that can serve admirably for these purposes.

It will count from less than 100 Hz to more than 40 MHz and display the input signal's frequency on a six-digit, multiplexed LED display. The counter uses CMOS and low-power Schottky IC's, bipolar transistors and a FET, allowing operation from alkaline and rechargeable Ni-Cd batteries.

**About the Circuit.** The frequency counter is illustrated schematically in Figs. 1 and 2. Input signals are coupled by *C1* to transistors *Q1* and *Q2*, which comprise a unity-gain buffer with a high input impedance. Diodes *D1* and *D2*, together with *R3*, protect the buffer from excessive input signal levels. A 10,000-series ECL triple line receiver, *IC1*, amplifies the voltage developed across *R5*. The third stage of this IC is used as a

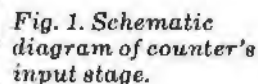
Schmitt trigger to square up the signal waveform. The output of *IC1* is applied to *Q3*. A TTL-compatible version of the input signal is available at the collector of this transistor. Hot-carrier diode *D3* is placed across the collector/base junction of *Q3* to prevent saturation, thus keeping the transistor's switching speed high.

Depending on the position of *S2*, (see Fig. 2), the output signal from *Q3* is applied to either *IC2* or *IC5*. When the switch is in the 4-MHz position, the signal is routed to *IC5*, an inverting buffer. When *S2* is placed in the 40-MHz position, *IC2*, a divide-by-10 prescaler, is inserted. The output of *IC2* is then buffered by *IC5*. Switch *S2* performs two other functions. The second switch pole passes current to the appropriate decimal point on display *DIS1*. The third pole selects one of two pull-up resistors (*R22* or *R23*) for the open-collector output of *IC5*. These resistors, along with *C14*, provide additional signal conditioning before the waveform is applied to CMOS counter *IC4*. This LSI chip contains all the circuitry necessary for counting.

latch, decode and drive functions, and interfaces directly with the display.

Integrated circuit *IC3* is the master clock. It consists of a crystal-controlled oscillator running at 6.5536 MHz and several dividing counters. Among its outputs are a 1600-Hz multiplex control signal and reset and gating pulses for *IC4*. Supply voltages of +5 and +10 volts are required. In the author's prototype, they are derived from series strings of four AA Ni-Cd and three AAA alkaline cells. Jack *J1* is used with an external charger, and *R<sub>x</sub>* is chosen to limit charging current to a safe value. Power supply bypassing is performed by *C3*, *C4*, *C5* and *C13*.

**Construction.** Suitable etching and drilling and parts placement guides are shown in Fig. 3. Begin by installing the six jumpers on the pc board. Then install IC sockets or Molex Soldercons, followed by the resistors. Mount all fixed capacitors on the component side of the board, except for C6 and C13. These capacitors and trimmer C12 are installed on their sides on the foil side of the



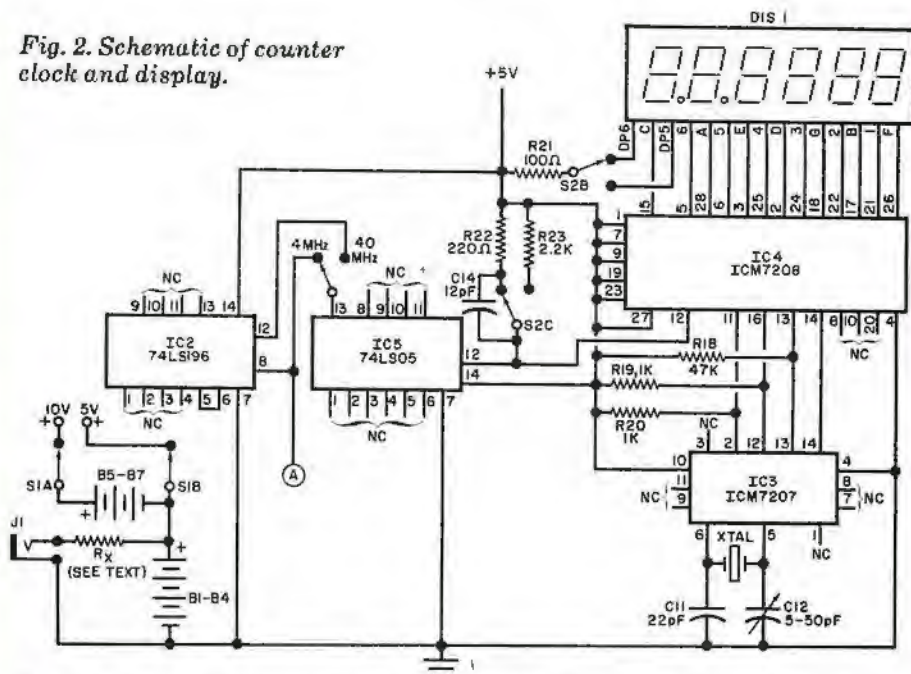


## PARTS LIST

B1 through B4—AA Ni-Cd cell  
 B5 through B7—AAA alkaline cell  
 C1, C3, C8, C10—0.1- $\mu$ F, 600-V disc ceramic capacitor  
 C2—68-pF disc ceramic or silver mica capacitor  
 C4—0.01  $\mu$ F disc ceramic capacitor  
 C5, C7—10- $\mu$ F, 16-volt tantalum capacitor  
 C6—33- $\mu$ F, 16-volt tantalum capacitor  
 C9—220-pF disc ceramic or silver mica capacitor  
 C11—22-pF disc ceramic or silver mica capacitor  
 C12—5-to-50-pF trimmer capacitor  
 C13—100- $\mu$ F, 16-V electrolytic capacitor  
 C14—12-pF disc ceramic or silver mica capacitor  
 D1, D2—MBD501 diode  
 D3—MBD101 diode  
 DIS1—Multiplexed LED display (see note)  
 IC1—MC10116 ECL triple line driver IC  
 IC2—74LS196 Schottky decade counter IC  
 IC3—ICM7207 LSI CMOS oscillator/divider IC (Intersil)  
 IC4—ICM7208 LSI CMOS counter IC  
 IC5—74LS05 Schottky inverting buffer IC  
 J1—Suitable jack for battery charger  
 Q1—MMT3823 n-channel FET (Motorola)  
 Q2—MMT2857 npn silicon transistor (Motorola)  
 Q3—2N3906 pnp silicon transistor  
 The following resistors are 1/4-watt, 10% tolerance.  
 R1—1 megohm  
 R2, R13, R15—330 ohms  
 R3—33,000 ohms  
 R4, R19, R20—1000 ohms  
 R5, R9 through R12—470 ohms  
 R6, R23—2200 ohms  
 R7, R21—100 ohms  
 R8—2700 ohms  
 R14, R22—220 ohms  
 R16—47 ohms  
 R17—150 ohms  
 R18—47,000 ohms  
 S1—Dpst switch  
 S2—3pdt switch  
 XTAL—6.5536-MHz quartz crystal  
 Misc.—Suitable enclosure, batteries and charger, battery holder, magnifying lens, solder, hook-up wire, IC sockets or Molex Soldercons, shielded cable, suitable probes, machine hardware, epoxy cement, electrical tape, etc.  
 Note—The following are available from Alpha Electronics (Texas), Box 64726, Dallas, TX 75206: Kit of parts and case (No. DFC-40) less input cable and probes, batteries and battery holder: \$50.00 plus \$3.00 postage and handling. Parts also available separately: 6.5536-MHz crystal, \$7.50 postpaid; etched and drilled printed circuit board (No. 280776) \$8.50 postpaid; DIS1 display (No. AE-9), \$6.00 postpaid; Bag of semiconductors including D1 through D3, IC3, IC4, Q1 and Q2, \$35.00 postpaid.

board. Observe polarities on all aluminum and tantalum electrolytic capacitors. The remaining fixed capacitor, C14, is mounted on the lugs of S2. Quartz crystal XTAL is installed on the foil side by bending its leads 90° and inserting them into the holes on the board.

Fig. 2. Schematic of counter clock and display.



Be sure the body of the crystal clears the foil under it before soldering.

Mount diodes D1, D2, D3 and transistor Q3 on the board, paying close attention to basing. The MMT transistors (Q1 and Q2) are soldered to the foil side of the board. Note that these transistors are color coded. Install Q1 so that its yellow dot is on the foil side and Q2 so that its orange dot is on the component side of the board.

The display assembly must be prepared before installation. Orient the assembly so that the numbers etched on the component side are toward you. Cut the cathode leads (the third from the left or middle lead on the bottom of the displays) of digits 1, 2 and 9 at the displays and unsolder them from the board. Cut the DP (decimal point) lead (fifth from the left at the bottom of the displays) at the board—not the displays—of digits 3 and 4 only. Clear the solder from the holes where the cathode leads of digits 1 and 2 went through the board. Run a short length of insulated wire from the hole where digit 1's cathode lead was connected to the decimal point lead of digit 3. Then repeat this procedure for the DP lead of digit 4 and the cathode hole for digit 2.

From now on, refer to digit 8 as denoted by the etched numeral as digit 1, digit 7 as digit 2 . . . and digit 3 as digit 6. Solder a straight pin into each display board hole except the fourth from the left and right-most holes. The pin heads should be flush with the component side of the display pc board. Place the display board over the main board and insert the pins into the holes in the main pc board. Space the boards 5/16" (8 mm) apart and solder the pins to the main

board. Clip the excess pin lengths from the foil side of the main board. Bend the display assembly so that it is at a 15° angle to the main board. When the counter is installed in its case, the display will be aligned for centered and properly magnified digits.

Bend the lugs of S1 and S2 90° and connect them to the pc board with short lengths of insulated hook-up wire. With S1 in the OFF position, wire four AA Ni-Cd cells in series between ground and S1B. Also connect a battery holder for three AAA alkaline cells between S1A and S1B. Wire a suitable charger jack to ground and to S1B via resistor R<sub>X</sub>. Select the value of R<sub>X</sub> to prevent (if necessary) your battery charger from overcharging the batteries. Connect the charger to J1 and allow the batteries to charge.

Install the IC's, following the standard precautions for handling MOS devices. Apply power by closing S1. Digits 1 and 2 (at the least) should light. Apply a 200-mV signal at 4 MHz or less across the counter input. With S2 in the 4-MHz position, check for a stable and accurate reading. Repeat this procedure with S2 set to 40 MHz and a 200-mV signal at 40 MHz or less.

Cut a display magnifier to size and install it in the counter's enclosure with epoxy cement. Mount S1 and S2. Install the pc board so that the display is properly centered and aligned. Then drill holes for J1 and the input cable. Insulate the batteries and the battery holder with electrical tape to prevent accidental shorts. Select suitable cable or wires for the input lead. Coax such as RG-58/U can be used, but its impedance is low and will tend to load down high-imped-



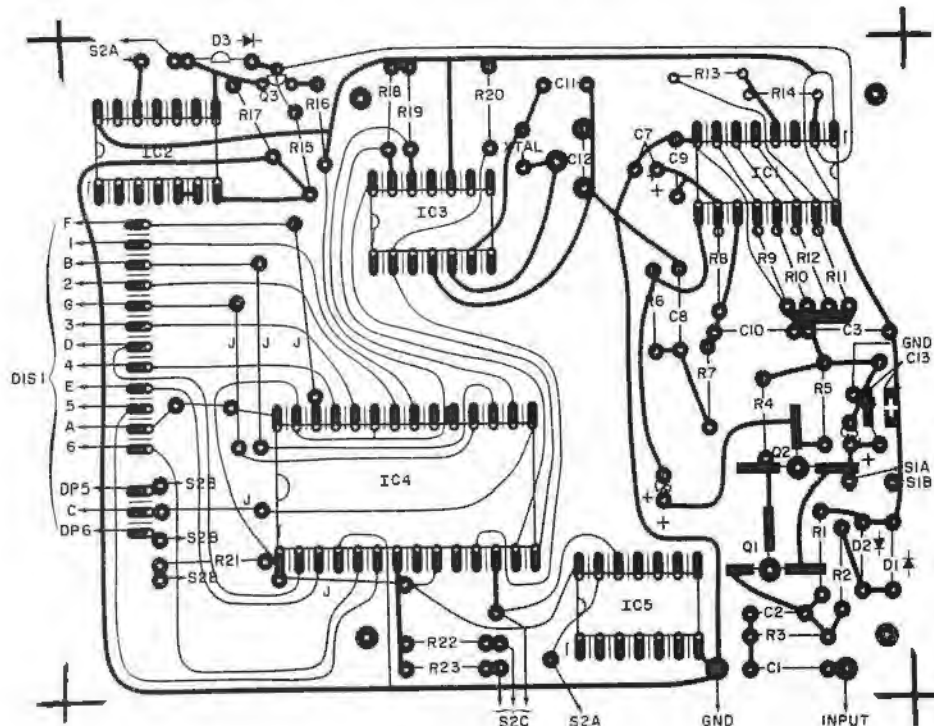
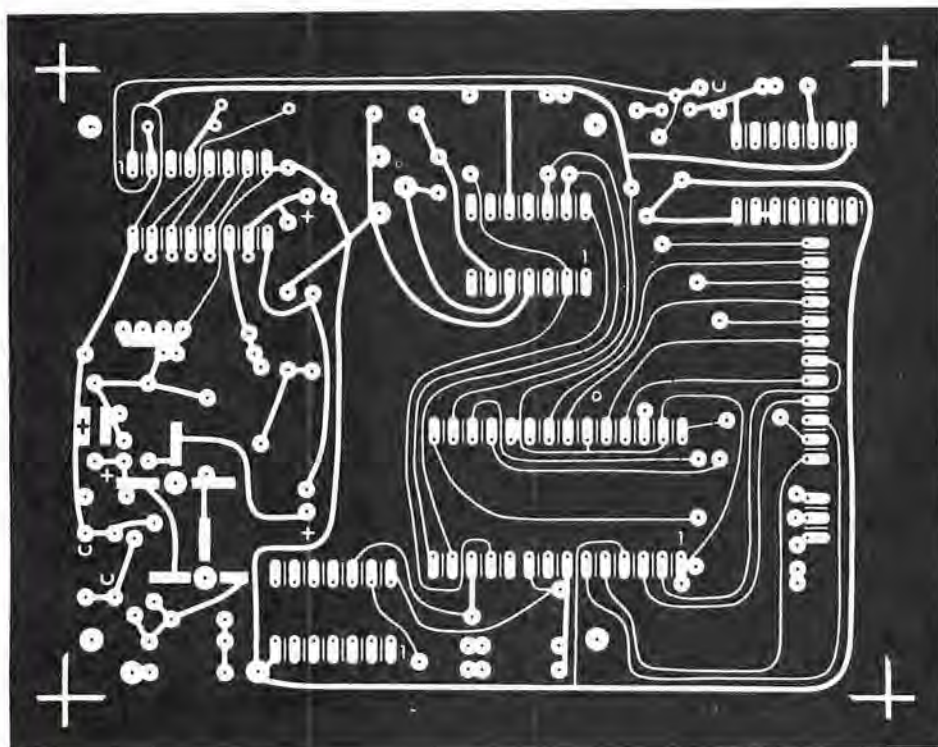


Fig. 3. Etching and drilling guide for pc board (left) and component layout (above).



ance circuits. Two separate shielded leads will work well and exhibit less of a loading effect. Solder the input lead(s) to the foil side of the pc board and run it (them) out through the hole in the enclosure. Mount J1 and place the alkaline cells in their holder.

**Calibration.** If a frequency counter or frequency standard is available, calibration can be performed merely by connecting a signal source of known fre-

quency to the counter input and adjusting C12 for an accurate reading. If no standard or counter is available, a signal generator can be zero-beat against WWV and used as a reference. The counter's accuracy can approach or exceed 0.00001%, depending on calibration accuracy.

**Using the Counter.** The sensitivity of this counter is nominally 200 mV from 100 Hz to 40 MHz. Operation beyond

these limits is possible if greater input levels are applied. Keep in mind that the input stage is protected to 50 volts. If the counter is to be used with an r-f transmitter, a short length of heavy, insulated wire may be used as an antenna to measure the output frequency. A ground is not required in this mode of operation. Frequencies will be displayed with 10-Hz resolution in the 4-megahertz range, and 100 Hz in the 40-megahertz range. ◇



# ACCURATE MILLIAMMETERS ON A BUDGET

*How to modify surplus-type meters to obtain high accuracy.*

BY DAVID CORBIN

**B**uying an ammeter with built-in shunts to measure currents from milliamperes to hundreds of amperes can be an expensive proposition. It is much less costly to obtain a basic 1-mA movement and add the shunts you need to create the necessary ranges. This can be done by using the table supplied here. It tells you what shunt values are required for a given milliammeter movement with a 1-mA full-scale swing.

**About Accuracy.** Depending on the movement you choose and how much you pay for it, basic accuracy will be between 1% and 5% full-scale. The accuracy figure is loosely based on both repeatability and scale precision. Bear in mind that the accuracy of large panel meters is generally no better than 1% full-scale. What these movements offer for the high prices they command are ruggedness, long life, temperature compensation, magnetic shielding, and high breakdown voltage, all of which may be important in some applications. Where the application is not critical, you can choose a small \$3.50 to \$6.00 panel meter and get more than adequate results.

When you look at accuracy figures for basic meter movements, be sure you understand the meaning of the figures. Since a current-measuring meter is placed in series with the source and load, it should have the lowest possible resistance for maximum sensitivity. The meter's resistance is a part of the circuit and affects the overall flow of current.

Let us assume that you have two meters, one with a 50-ohm resistance and the other with a 100-ohm resistance. If you were to insert the 100-ohm meter into a circuit with 100 ohms resistance in which the actual current flow is 1 mA, the meter would indicate 0.5 mA. Substituting the 50-ohm meter would yield a 0.67-mA reading. The readings obtained are the actual currents flowing in the circuit while the meters are in the circuit and they are within 1% of the actual current. (Of course, if you remove the meters, the current in the circuit would again become 1 mA.) The discrepancies are the result of the fact that the meters add their own resistance to the circuit and reduce the overall current flow.

If the meters had zero resistance (impossible to achieve in practice), they would not affect the flow of current. In this case, both meters would indicate 1 mA. It is obvious then that, in the world of real measurements, you must take into account the effect the meter has on the circuit that is being tested.

**Custom Tailoring.** Since the voltage it takes to swing the milliammeter's pointer to full-scale is the product of full-scale current times coil resistance, it is easy to design circuits and make reference charts for choosing shunt and series-shunt combinations. It is amazing how small a voltage is required for a full-scale pointer swing on a typical 1-mA movement. For example, a 50-ohm, 1-mA movement requires  $1 \text{ mA} \times 50 \text{ ohms}$ , or 50 mV (0.050 V) full-scale.

The problem is that many low-cost meter movements are provided with no specifications other than the scale markings. You cannot measure the coil resistance with an ohmmeter because the test voltage is much too high and can damage the movement or burn out the meter's coil. The best way to check milliammeter movements is with a simple

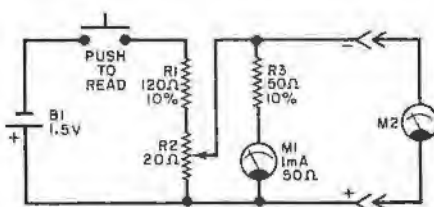
0.1 volt or as 0 to 100 ohms. Potentiometer *R2* is adjusted for a full-scale reading on *M1*.

Once you know coil resistance  $R_M$  and full-scale voltage  $E_M$ , as indicated on *M2*, you can calculate the shunts needed to increase the basic movement's range. The formula for this is  $R_S = E_M / (I_D - I_M)$  where  $R_S$  is the shunt resistance in ohms and  $I_D$  and  $I_M$  are the design and movement's full-scale currents in amperes. However, to avoid having to perform the mathematics, you can refer instead to the table, which gives the values of the shunt resistors needed for various 1-mA meter movements for a variety of full-scale ranges. The resistances in the table are rounded off to three places in most cases. It isn't necessary to be too accurate in shunt-resistor selection because of the limitations resulting from the built-in errors of the basic meter movement itself.

About the best possible accuracy you will be able to obtain, no matter how precise the values of the shunt resistors, will be 1% of the full-scale reading. The resistors you use will not normally be better than 1% to 5%, and the meter movement itself cannot be interpreted to better than 1% accuracy even if it is the best available.

The 1-mA movement will probably be calibrated in 10 major divisions, with five minor divisions between each. This works out to 0.1-mA major and 0.02-mA minor steps when only the basic measuring range of the movement is considered. When multiplied by the shunt factor for a 50-mA full-scale reading, the major steps are each 5 mA and the minor steps are each 1 mA. However, without an antiparallax mirror backing on the movement and other refinements, one minor division is about the limit of what you can interpret on any reading.

Thus, a 1-mA error is possible in the reading and 0.5 mA in the meter's basic accuracy. In terms of a shunt, assuming a 50-ohm movement, this is like using a 1-ohm resistor instead of the required 1.02 ohms. In fact, the difference of 0.5 mA caused by the movement itself would be the same as an error of from 1.0098884 to 1.0309278 ohms instead of the exact 1.0204081 ohms required.



*Fig. 1. Here is a simple meter calibration circuit you can use to check meter movements.*

meter calibration circuit like that shown in Fig. 1. For this, you will need a good standard multimeter capable of indicating current to 1 mA full-scale. (Even a \$6 basic movement will do if its coil resistance is specified.)

The meter calibrator shown in Fig. 1 uses a 50-ohm movement. This movement indicates half of the voltage dropped across tested movement *M1*. The total reading from *M2* is read as 0 to



## SHUNTS NEEDED FOR VARIOUS MOVEMENT RESISTANCES AND FULL-SCALE CURRENT

Movement (ohms) Current (mA)	Shunt (ohms)				
	12.5	25	50	75	100
5	3.13	6.25	12.5	18.75	25.0
10	1.39	2.78	5.56	8.33	11.1
25	0.52	1.04	2.08	3.13	4.17
50	0.26	0.51	1.02	1.53	2.04
75	0.17	0.34	0.68	1.01	1.35
100	0.13	0.25	0.51	0.76	1.01
150	0.08	0.17	0.34	0.50	0.67
200	0.06	0.13	0.25	0.38	0.50
500	0.025	0.05	0.10	0.15	0.20
1000	0.0125	0.025	0.05	0.075	0.10
10,000	0.00125	0.0025	0.005	0.0075	0.01

This simply points out the limit of accuracy to be expected with any moving-coil type of meter. Needless to say, the home-built metering circuit can be as accurate as the best commercial analog meters.

To avoid having to wind special resistors, you can use combinations of standard resistor values to make the required shunts because the precision required for good results will not be excessive. The formula for determining the

value of the parallel resistor needed for a given shunt value and given one resistor of known value is  $R_U = R_S R_K / (R_K - R_S)$ , where  $R_U$  is the resistance to be found,  $R_S$  is the desired shunt resistance, and  $R_K$  is the value of the known resistor. To obtain a good many values with odd decimal endings, a fractional value resistor can be used in series with a standard larger value resistor. Of course, the accuracy will suffer when the possible errors of the resistor values are added to the circuit. However, if you use 1% and 5% tolerance resistors and the scale multiplication is large, the amount of overall error will be in the same range as the limits of the meter movement itself and will not have much effect on the accuracy of the reading.

The power that is generated in the shunt must be handled without excessive heating of the shunt or the values of the shunt resistors will change. By using resistors with 50% greater heat dissipation (power rating) than is actually required, you will not exceed safe limits. Even with a 10-ampere shunt, the current is not large enough to generate much heat in a 0.01-ohm load. The power generated will be 1 watt, so a 2-watt resistor will be more than adequate. Smaller currents develop correspondingly lower power in the shunts. The formula for calculating the power rating of the shunt resistors is  $P = 1.5 E_M (I_D - 0.001)$ , where  $P$  is the power in watts,  $E_M$  is full-scale meter voltage in volts, and 0.001 is the value of the 1-mA meter movement's full-scale current.

To measure higher currents without having to resort to very small values of resistors and resistor combinations for the shunts, a dropping resistor can be

placed in series with the meter movement. (Various configurations of shunt circuits are shown in Fig. 2. The Fig. 2D circuit illustrates the resistor placed in series with the meter movement.) If you know the value required for shunt resistor  $R_S$ , the formula for determining the value of dropping resistor  $R_D$  is  $R_D = [R_S (I_D - 0.001) - E_M] / 0.001$ , where  $R_D$  is in ohms,  $I_D$  is in amperes, and 0.001 is the full-range current of the meter movement. To find  $R_S$  when the total drop is specified, use the formula  $R_S = E_{RS} / (I_D - 0.001)$ . Then  $R_D = (E_{RS} - E_M) / 0.001$ .

The Fig. 2D circuit can be used when a certain voltage drop is required in a metering circuit and it is different from the drop that would result from using a standard shunt circuit. It is also handy for avoiding small values of resistance, but the pitfall is excessive power loss through the shunt when measuring high currents.

The power in the shunt is calculated by subtracting 1 mA from the design current ( $I_D$ ) and multiplying this times the voltage drop across the shunt, which is the same as the total circuit drop. Almost any value of resistance can be used for the shunt, but the power rating will go up in direct proportion to the resistance for any given current measurement. The biggest advantage will be in the avoidance of odd-value shunt resistors that cannot readily be obtained by connecting resistors in parallel or series-parallel configurations.

Multirange general-purpose meters can be made by using a combination of simple shunt and series-shunt networks and a multi-position switch. The lower ranges, where shunts are obtainable in close-to-standard values, can have the shunts switched directly across the meter movement.

**Summing Up.** The design of current-measuring circuits in which a standard 1-mA meter movement is used is applicable to even the most limited budget and available test equipment. It provides accurate current monitoring in up to four decade ranges at a typical cost of less than \$15. A single-value monitor circuit can be installed in a project for less than \$9, and it will provide an accuracy of between 1% and 5% full-scale, depending on the care taken during the design stages. The problem of finding and stocking a variety of current meters is solved by keeping one or two milliammeter movements handy and making up a few standard shunt circuits to use with them as described here. ◇

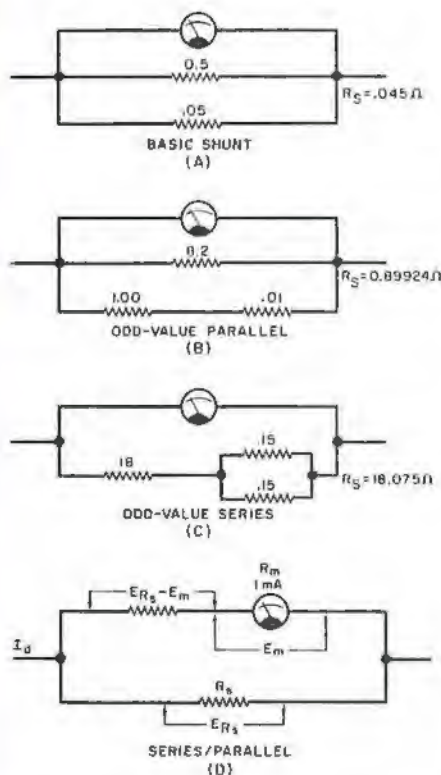
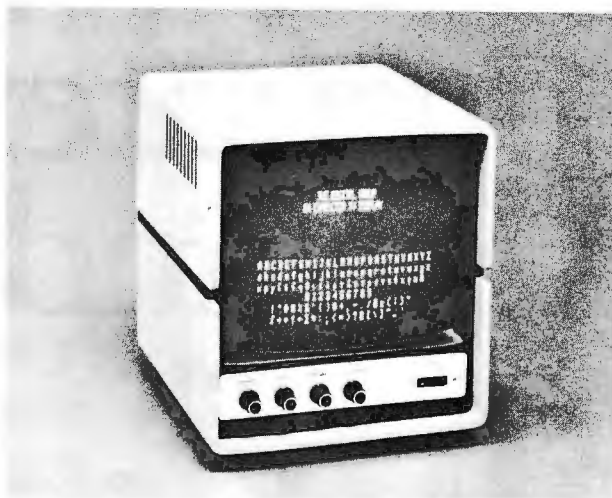


Fig. 2. Various configurations for using shunts with meters.



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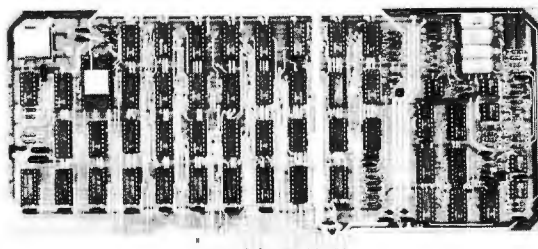
Here are the specifics on the Digital Group TV Readout and Audio Cassette Interface:

### 1024 Character TV Readout

- 64 characters horizontal by 16 lines
- 7x9 character matrix (effectively 7x12 due to character shifting)
- 1K on-board RAM for buffer storage—requires no main memory—completely independent
- 128 character ASCII
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  - Lower case alpha with base line extenders (g, j, p, y)
  - Numbers and extended math symbols
  - Greek alphabet
- Software driven cursor—forward and backward
- Compatible with most microprocessors; Interfaces with 18-bit parallel output port
- Timebase may be driven with an external timebase (may be synchronized to TV camera, TV set, etc.)
- Readout timebase available at connector (can be used for graphic driver, etc.)
- White characters on black, and/or black on white; software selectable
- Plugs into standard dual 22-pin TVC connector on Digital Group Systems

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- Reliable FSK recording technique
- Uses standard unmodified audio cassette recorder



- Write cassette system uses a digitally synthesized frequency shift system, derived from TV system's master crystal oscillator
- Read cassette system easily aligned using the write system as an alignment aid.
- Runs at 1100 baud (100 characters/second)—loads 16K in 3 minutes

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### Prices:

TVC-64—Full 64-character TV Readout & Audio Cassette Interface:

Kit — \$140      Assembled — \$205

TVC-64UPG—Upgrade kit from TVC-F:

Kit — \$65

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# How Computers Detect and Correct Transmission Errors

*Parity checking and redundancy are two of the devices used in error detection.*

BY JEROME MAY

**A**LMOST everyone has had some experience in dealing with a computer mixup. One classic story goes like this: a computer, doing one of the earliest payroll jobs, put a 1 where a zero should have been, and the next week the janitor picked up his paycheck for exactly \$1,000,147.38!!

Systems engineers and serious microprocessor hobbyists are aware of the problems that random noise can cause

on data lines. Noise can cause the "three" that was sent to show up as a "seven."

Because "error" can be treated as a random event, having equal likelihood of occurring in any given datum, it becomes possible to apply techniques of *information theory, probability, and statistics* toward designing systems that are resistant to this type of error.

A simplifying assumption that will be

useful is that, in a data word consisting of  $n$  bits, only *one* bit will be in error. The treatment of multiple-error-detecting systems uses methods similar to those discussed, but the treatment becomes extremely mathematical and complicated and is beyond the scope of an introductory article.

**Redundancy.** An error can be detected by redundancy, which is the inclusion of extra information with each data transmission. This extra information helps the receiver to decide if the data it has received has been altered in transmission.

Obviously, the simplest error detecting system, conceptually, would be the transmission of each data unit twice. Thus, if the first transmission does not match the second transmission, the receiver can signal that an error has occurred and to please repeat the data.

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Restating the problem, the decimal

DECIMAL	BINARY	BCD	EXCESS-3	GRAY CODE	DECIMAL
0	0000	0000	0011	0000	0
1	0001	0001	0100	0001	1
2	0010	0010	0101	0011	2
3	0011	0011	0110	0010	3
4	0100	0100	0111	0110	4
5	0101	0101	1000	0111	5
6	0110	0110	1001	0101	6
7	0111	0111	1010	0100	7
8	1000	1000	1011	1100	8
9	1001	1001	1100	1101	9
10	1010	xx	xx	1111	10
11	1011	xx	xx	1110	11
12	1100	xx	xx	1010	12
13	1101	xx	xx	1011	13
14	1110	xx	xx	1001	14
15	1111	xx	xx	1000	15

Fig. 1. Five different 4-bit codes for the decimals 0 through 15.



numbers 0 through 15 have exactly 16 representations in binary, as shown in Fig. 1. Since all possible combinations of 0 and 1 in four positions are used, there is no way to detect datum error because all combinations are equally likely; there is no room for redundancy.

**Binary-Coded Decimal.** Suppose only the decimal digits, 0 through 9, are to be transmitted. From these 10 digits any positive decimal integer can be constructed. The 10 binary representations for these digits are known as *binary-coded decimal*, or BCD.

In BCD the codes for the numbers 10 through 15 decimal are not used and, if they show up at a receiver, they can be detected as "illegal" by checking the received datum with a "legal word" list. By selecting BCD over straight binary, a designer makes it possible to detect one type of error.

**Excess-Three Code.** By making a simple change to the code, more information—redundancy—can be built right in. The *excess-three* (X-3) code is obtained by adding binary 0011 to the BCD codes for the decimal digits 0 through 9. Figure 1 shows that X-3 does not allow the codes 0000 or 1111. Thus, every legal X-3 word contains at least one 0 and 1, providing another bit of information—that the data channel is active and transmitting.

Another property that makes it interesting for error-checking is that X-3 is a *self-complementary* code. That is, if each 0 of a legal X-3 word is changed to a 1, and each 1 to 0, the process generates the 9's complement of the word. This feature makes error-checking in X-3 easier and statistically more reliable than BCD codes. In a BCD error-checking algorithm, for example, a minimum of six comparisons and table look-ups must be made before an error can possibly be detected.

BCD is a *weighted positional* code; in which the position of each bit in the data word determines its value. X-3 is not a weighted positional code. By counting 1's and 0's in each position of the X-3 representation of the digits 0 through 9, it can be seen that for a given X-3 word, each position has a 50% probability of being either 0 or 1. This eliminates any statistical bias in the code itself.

In an X-3 error-checking algorithm, with judicious use of the "complement" function (a very fast and very easy operation in most microprocessors), the algorithm can detect a bad code in six comparisons but only two memory look-

ups. In some cases, the error checking can be done 100% faster by use of the X-3 code for data transmission.

As a further bonus, the X-3 code makes keeping track of carries and borrows in addition and subtraction of coded decimal digits significantly simpler than in the straight BCD code.

**Gray Code.** Turning to a completely different four-bit code, the *Gray code* finds an application in many analog-to-digital data-transmission systems. The Gray code's most significant feature is that, going from one number to another with a difference of only one, only a single bit changes in the Gray code. In a system where the analog signal is expected to change slowly with respect to the sample frequency (say, for example, temperature inside a house is being monitored and encoded), a change in more than one digit position would automatically signal an error to the receiver.

Some information—more redundancy—about the data itself is reflected in the code itself. The odd decimal digits (1, 3, 5 etc.) have Gray-code equivalents that contain an *odd* number of 0's and 1's. This extra information is designed right into the code system itself, taking advantage of its most likely application.

So far, discussion has been restricted to four-bit codes. This has been done keeping in mind the 8-bit data bus structures of microprocessors such as the 8008, 8080, or 6502. With more complicated codes, however, it is possible to add an extra bit to the data word to contain extra information about the data.

**Parity.** One of the more widely used complicated coding systems is called *parity checking*. Parity checking simply counts the number of 0's or 1's in a data word and assigns a value to an extra *parity bit*, depending on the result (Fig. 2). Thus a seven-bit code such as ASCII (American Standard Code for Information Interchange) might be transmitted in an eight-bit format, with one parity bit.

The *odd parity* system adds a 1 to a data word so that it always has an *odd* number of 1's in it. *Even parity* adds a 1 to cause an even number of 1's. Odd parity has a slight advantage, similar to excess-three, because every code word has at least one 1 or 0 in it, providing a verification of data-channel operation.

Note that with the parity system, if two errors occur in the same data word, parity check will not detect the error! But it will detect a three-bit error, or an error in any odd number of different bits.

DECIMAL	BINARY	PARITY
0	0000	1
1	0001	0
2	0010	0
3	0011	1
4	0100	0
5	0101	1
6	0110	1
7	0111	0
8	1000	0
9	1001	1
10	1010	1
11	1011	0
12	1100	1
13	1101	0
14	1110	0
15	1111	1

Fig. 2. Binary codes and odd-parity digits for decimal numbers 0 through 15.



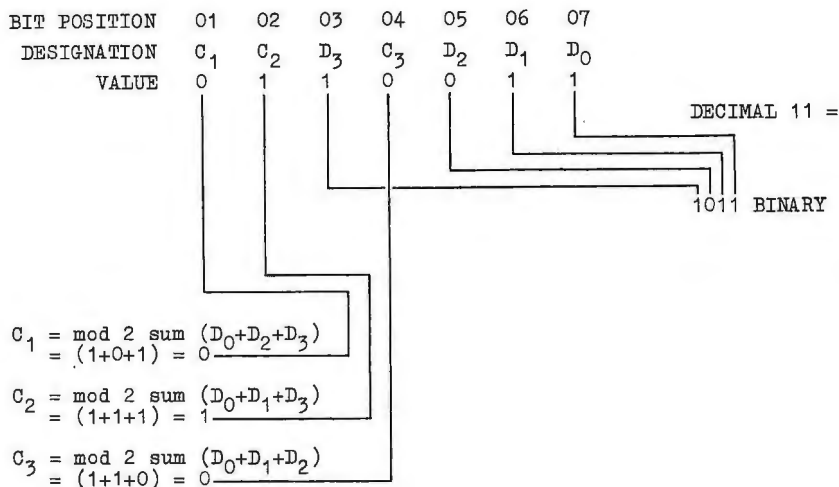


Fig. 3A. How Hamming-code check digits are generated.

	01	02	03	04	05	06	07
	C <sub>1</sub>	C <sub>2</sub>	D <sub>3</sub>	C <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
RECEIVED VALUE	0	1	1	0	0	1	1

$$C_1' = \text{mod } 2 \text{ sum } (C_1 + D_0 + D_2 + D_3) = (0 + 1 + 0 + 1) = 0$$

$$C_2' = \text{mod } 2 \text{ sum } (C_2 + D_0 + D_1 + D_3) = (1 + 1 + 1 + 1) = 0 \quad (C_3', C_2', C_1') = (0, 0, 0)$$

$$C_3' = \text{mod } 2 \text{ sum } (C_3 + D_0 + D_1 + D_2) = (0 + 1 + 1 + 0) = 0 \quad \text{NO ERROR}$$

Fig. 3B. Check digits show that word was transmitted correctly.

	01	02	03	04	05	06	07
	C <sub>1</sub>	C <sub>2</sub>	D <sub>3</sub>	C <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
RECEIVED VALUE	0	1	1	0	0	0	1

$$C_1' = \text{mod } 2 \text{ sum } (C_1 + D_0 + D_2 + D_3) = (0 + 1 + 0 + 1) = 0$$

$$C_2' = \text{mod } 2 \text{ sum } (C_2 + D_0 + D_1 + D_3) = (1 + 1 + 0 + 1) = 1 \quad C_3', C_2', C_1' = (1, 1, 0)$$

$$C_3' = \text{mod } 2 \text{ sum } (C_3 + D_0 + D_1 + D_2) = (0 + 1 + 0 + 0) = 1 \quad \text{ERROR IN BIT 6}$$

Fig. 3C. The check digits show the error is in bit 6.

	01	02	03	04	05	06	07
	C <sub>1</sub>	C <sub>2</sub>	D <sub>3</sub>	C <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
RECEIVED VALUE	0	0	1	0	0	1	1

$$C_1' = \text{mod } 2 \text{ sum } (C_1 + D_0 + D_2 + D_3) = (0 + 1 + 0 + 1) = 0$$

$$C_2' = \text{mod } 2 \text{ sum } (C_2 + D_0 + D_1 + D_3) = (0 + 1 + 1 + 1) = 1 \quad (C_3', C_2', C_1') = (0, 1, 0)$$

$$C_3' = \text{mod } 2 \text{ sum } (C_3 + D_0 + D_1 + D_2) = (0 + 1 + 1 + 0) = 0 \quad \text{ERROR IN BIT 2}$$

Fig. 3D. The check digits show an error in bit 2, proof that even the error-protect digits are safe from error.

**Multiple Errors.** So far, the code structures and error-checking systems have provided enough redundancy to provide for some manner of single-error checking. But all fail pretty badly at detecting more than one error per datum.

Is single-error detection enough? Statistics (and the binomial theorem) say that for an error rate of one in 1000 transmitted bits, the odds of having two erroneous bits in a 5-bit word are one in 100,000. So, the single-error approximation seems a realistic, although simplistic, choice.

The amount of redundancy in an error-correcting code must be much higher than in a mere error-detecting code. Mathematicians, using such esoteric items as group theory, vector spaces and cyclic codes, have come up with a whole flock of codes that contain information about themselves, but most of them are best applicable when large bit-strings are processed.

**Hamming Code.** One of the simplest error-correcting codes is called the *Hamming code*, after its developer. The Hamming system for a four-bit datum, for example, generates three check bits, and the data must be transmitted in a particular manner (that is, the check and data bits interspersed in a particular manner) in order for the decoding and verification to correctly occur.

Suppose the decimal number 11 is to be transmitted. The binary representation is arranged in the indicated positions of the data word, in Fig. 3A and the check digits are generated by following the rules shown. The *modulo 2 sum* is the remainder (0 or 1) after adding a string of binary digits and disregarding any carry operations. The check digits go into the positions shown.

The resulting seven-bit word is now transmitted. The error-checking and results for a word transmitted with no error is shown in Fig. 3B.

Figure 3C shows the seven-bit word received with an error in data digit D<sub>1</sub> in bit position 6. Note that, when the verification digits (C<sub>3</sub>', C<sub>2</sub>', C<sub>1</sub>') are arranged as a three-bit binary number, they point right to the erroneous bit—the number 110 in binary is 6 decimal.

Figure 3D shows the seven-bit word received with an error in check digit C<sub>2</sub>. The verification digits now form the binary number 010, bit position 2, where the error is!

Again, note that if two errors occur, it is impossible to completely reconstruct the data word with this given scheme. Multiple-error-correction codes do exist, however. ◇



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# CREATIVE RECORDING WITH 4-CHANNEL TAPE RECORDERS

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*How to achieve special effects such as echo, reverb,  
and balancing for stereo level and position.*

BY LEONARD FELDMAN

**A**CCORDING to several audio dealers surveyed recently, one of the hottest items in all of high-fidelity componentry is the 4-channel, open-reel tape deck. Of course, sales of these multi-track machines don't even come close to those of better stereo cassette decks, but when you consider the fact that reasonably good 4-channel decks sell for around \$600.00 and up, as opposed to Dolby-equipped cassette machines that can be had for as little as \$200.00 or sometimes less, consumer interest in the open-reel format seems unusual.

Add to this the fact that very few recording companies offer even a meager selection of pre-recorded 4-channel programming on open-reel tapes and the sudden interest in these expensive machines becomes even more puzzling. Surely, owners of 4-channel, open-reel decks are not spending that kind of money simply to transcribe their newly acquired CD-4 or matrix 4-channel records onto tape, although of course that is one application for these quadraphonic recorders.

A clue to the most popular usage of these machines was uncovered by further questioning of dealers and by thumbing through some of the recent product offerings from manufacturers who normally concentrate on such conventional products as tuners, amplifiers,

and receivers. They are now offering such "odd-ball" products as mixers and portable mixing consoles for consumer use. These include Shure, Teac, Sony, and others. Some of their mixers have six or more input channels and up to four output-channel facilities.

In addition, we found that microphone sales are better than ever at the consumer level, and we don't mean single microphone purchases to replace the original-equipment models supplied with cassette decks. We're talking about good dynamic and condenser microphones that sell from \$50.00 and up. These are finding their way into home hi-fi systems in increasing numbers, as are separate Dolby noise-reduction systems, compress-expand systems, and others. From all this sales activity, we concluded that the big 4-channel decks aren't necessarily being used to record or play 4-channel programming at all! They are forming the basis of thousands of "home recording studios," often capable of turning out master tapes that rival some of the products made by professional studios.

**"Sel-Sync" Makes the Difference.** At least five makes of multi-track tape decks sold to consumers have an important built-in feature that enables users to employ some of the same techniques used in recording popular music.

While just about any stereo or 4-channel deck is equipped with three tape heads (erase, record, and playback), the physical position of these heads in relation to tape travel is normally that shown in Fig. 1. The tape passes across the erase head first, where any previously recorded material is erased. Desired new program information is then recorded onto the tape as it passes in front of the record head and, a fraction of a second later, the newly recorded program can be "monitored" by the playback head and the playback preamplifier associated with that head.

This is a fine arrangement for making ordinary stereo or even 4-channel recordings, since it enables the operator to hear his recorded results (either via phones or through his speaker system) just a short time after the recording occurs. If he hears distortion, over-recording, or under-recording, he can correct control settings *almost* instantly. The delay is determined by the distance between the record and playback heads (in inches) divided by the tape speed (in inches-per-second). The faster the tape speed, the shorter the delay.

Suppose, however, that you wanted to record one tape track at a time, adding other tracks later. You might want to record the singing of a "one man quartet"—in which you or a talented friend provide all four harmonizing vocal parts



*Pioneer's Model RT-2044 four-channel tape deck has "Synchromonitor" mechanism for sound-on-sound and sound-with-sound.*



head from being connected to playback electronics and used as a playback head. If the record head were designed to do its best job in the recording function, chances are it would not exhibit the greatest frequency response or signal-to-noise characteristics when used as a playback head. However, if the sole purpose of its transition to a playback head is to enable recording artists to synchronize their efforts with previously recorded tracks, fidelity of reproduction heard through the monitoring phones is not that important.

The principle of Sel-Sync is shown in Fig. 2. A single track (say, track 1) is recorded by the first program source. Recorders equipped with Sel-Sync will have a switch (usually a two-position slide switch) associated with each recording track. In the diagram, the switch is set to its normal or "record" position, thereby connecting the track-1 record coil and gap to the record electronics. After the tape is rewound, the track-1 Sel-Sync switch is moved to its alternate position, connecting the track-1 coil to the playback preamplifier. All other record tracks remain connected to their respective record electronics, so that any one of them can now be recorded while listening to the results recorded onto track 1.

This procedure can be repeated until all four tracks have been individually recorded. Any one of the successively recorded programs can be used as the "monitoring" channel, except, of course, the track currently being used for the new track then being "laid down." If desired, two previously recorded tracks may be monitored simultaneously while the third is being added, so that the performer can hear both earlier recorded

by making four separate single-track recordings which you would later mix together. With the head arrangement shown in Fig. 1, there is no way in which you could record the second, third, and fourth tracks in perfect synchronism with the first recorded track. Even listening with phones (so that the previously recorded track would not be picked up by your "live" mike), your newly added vocal part would be applied to track 2 just a little too late and, if you listened to a playback of track 2 and tried to add the track-3 program, it would be farther behind and so on.

This is where the principle of "Sel-Sync" comes in. It's an abbreviation for selective synchronization. Sel-Sync is the tradename used by Ampex, the well-known maker of professional tape equipment. It arises from the need to hear previously recorded tracks while simultaneously recording another signal in synchronization with them on the same piece of tape. It is the principle of Sel-Sync which is involved in many of the modern recording procedures in studios around the country.

Contrary to popular belief, most contemporary recordings are not recordings of "live" musical events at all. Using as many as 16, 24, or even more tape tracks, recording engineers assign single instruments or voices to one or more of these tracks. Very often, individual tracks may be recorded at different times—even in different studios. A master recording will contain all of the individually recorded tracks and these are then "mixed down" by the recording en-

gineer, often with the aid of the producer and the artists themselves. It is during this mix-down process that individual tracks may be equalized ("sweetened" is the term used in the trade), augmented by echo or reverberation effects, rebalanced in terms of relative levels and positioned in the stereo or quadraphonic sound field. Sophisticated as these secondary steps may be, none of them would be possible were it not for Sel-Sync, which permitted the synchronization of all tracks in the first place.

**How Sel-Sync Works:** Although a record tape head is designed for optimum performance during its record function, there is really nothing to prevent one or more coils of the multi-track



*The Otari MX-5050-QXH has "Sel/Rep" for recording two discrete but time-synchronized tracks.*



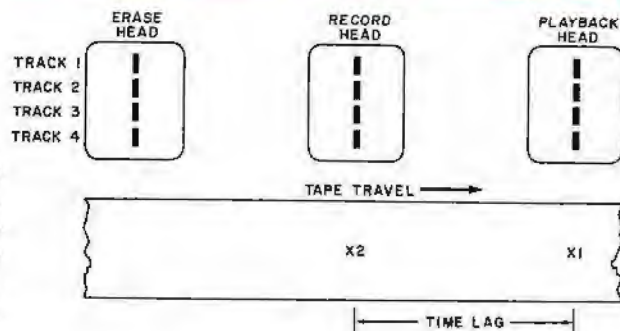


Fig. 1. If track 2 is recorded while listening to track 1's playback head, there is time lag between the programs.

tracks while adding his third track, and so forth. If there is acoustic isolation between the playback systems and the performing artist, monitoring can be done by the "home recording engineer" over speakers while the performer uses phones for the same purpose.

The possibilities are almost endless and, if you use your hi-fi component system for playback (assuming it's a 4-channel system for a quadraphonic mix attempt or a stereo system of a 2-channel mix-down) the tape output jacks of the receiver or amplifier can now be fed to a second deck (open-reel or cassette) onto which your properly mixed-down version of the recording can be recorded. It is at this point that mixers become most useful, since each of the four "raw" tracks can now be treated as a signal source into the mixer, which, depending on its flexibility and control features, becomes your home-recording console. Even without this addition, you'll find that 4-channel decks equipped with Sel-Sync also have individual level controls for each channel or track which enable you to balance relative levels before the final "master" mix-down or dubbing is made.

At least five manufacturers we know of have 4-channel open-reel decks

available that include the selective synchronization feature. Teac offers the feature, which it calls "Simul-Sync," on its Models 3340S and 2340R machines. The chief difference between the two is that the lower priced 2340R unit accepts 7" reels and operates at 3¾ and 7½-ips speeds, while the costlier version accepts 10" reels and operates at 7½ and

Model 1140, both with electronic echo, sound-on-sound, and sound-with-sound recording. Otari's MX-5050-OXH calls its version "SEL/REP," while Pioneer calls it "Synchomonitor." All of these machines have individual mike and line mixing controls for each channel, affording a great measure of flexibility even if a separate multi-channel mixer is not part of your home-recording set-up.

We visited a home-recording set-up which included a Teac 3340 and an Akai. With two decks, this enthusiast is able to do Sel-Sync recording of his masters and then transcribe the results, properly mixed and re-blended, to the second deck. The photos show close-ups of the Simul-Sync switches on the Teac machine and the equivalent push-button switches (one for each track) on the Akai unit.

**Noise Reduction:** A pair of Dolby noise-reduction units is used with these 4-channel decks. Why add Dolby to

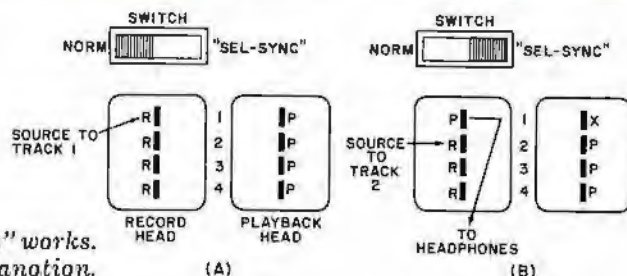


Fig. 2. How "Sel-Sync" works. See text for explanation.

15-ips tape speeds. In Akai's GX-630SS 4-channel deck, the feature is called "Quadra-Sync." This machine operates at two speeds and accepts large-size tape reels. Dokorder's synchronizing function is called "Multi-Sync," and is found on their 3¾-7½-ips, 7"-reel Model 7140 and their 7½-15-ips, 10½"-reel

such fine decks, each of which can easily produce a signal-to-noise ratio of 60 dB or more when used with quality tape? Simply because if you're going to do any dubbing (successive copying of tape-to-tape), each dubbing process will add a few dB of noise to the finished product, so you want to start out with every last



Closeup of "Simul-Sync" track switches on Teac 3340.



Akai "Quadra-Sync" track-selector buttons.



dB of signal-to-noise you can get. In this particular "home studio," the Dolby units are hooked up to the Teac deck, which serves as the master recorder. Dolby decoding is used during playback as the raw tracks are re-recorded onto the Akai machine, thereby affording more "head-room" to the finished mixed-down master tape.

Often the owner of this set-up has to transcribe his master tapes onto a cassette. To achieve best signal-to-noise ratio here, he uses a dbx Series 122 2-channel noise-reduction system. Working on a different principle from Dolby, this unit compresses the recorded material by 2 to 1 during recording and then, when the proper buttons are pushed, re-expands the program during playback by the same factor. The combined action increases the dynamic range by a wide margin while reducing noise and is especially useful with cassettes where over-recording or tape saturation is much more of a problem than with open-reel units.

**Other Applications.** You can simulate four-channel sound when recording two-channel (some old stereo tapes, perhaps) by returning the monitor output to the record head. In effect, you use the time delay between the playback and record heads to obtain an echo effect.

A tape technique that's mind-boggling is sound that circles the room. This can be accomplished with a "pan pot" to gradually move the sound from one channel to another. (Two Teac AX-10 stereo echo units make it easy to achieve such results, by the way. They enable a user to vary the degree of echo and incorporate impedance-matching networks.)

Having four independent channels at



*Sony Model MX-510, a 5-input, 2-output mixer unit.*

hand, all in perfect synchronization, offers new recording opportunities. From the standpoint of quality, it beats sound-on-sound since the former is a second-generation recording (recorded on the originally recorded track) with attendant fidelity losses, while a Sel-Sync deck can provide first-generation tapes. So now it's easy to make four independent recordings (actually you can make seven first-generation recordings by using mix-down techniques). What can you do with at least four tracks? For starters, one track can be used for voice, a second for background music, a third for special effects, a fourth for voice-over or another voice, perhaps singing or whatever else you choose. You're only limited by your imagination.

**Isn't a Studio Cheaper?** The equipment described here—which does not include any microphones or even the cassette machine used—adds up to nearly \$4000.00. The question naturally arises whether a serious recordist (or musical group, or singer, or instrumentalist) wouldn't be better off renting time at a professional recording studio. Well,

perhaps he would, but these days, studio time sells for upwards of \$100.00 an hour if you're talking about a top studio—and the hours have a way of ticking by as you wait for studio set-up, do several unsuccessful takes, wait for an acceptable mix-down, and the like. With so many aspiring groups around, it's not surprising that they opt for a home set-up not unlike the one described, for then they can afford to do as many "takes" as are necessary for a good "auditioning tape."

More than one successful recording group has used this approach to "breaking in" to the entertainment field, and stories of these successes have led other aspirants to make the investment in this kind of equipment. By way of comparison, even the relatively moderately priced mixing console manufactured by Tascam (the professional division of Teac), and considered to be the logical "bridge" between consumer equipment and truly professional studio console equipment, costs nearly \$2000.00 in its most elementary form. It can run several thousands more when equipped to maximum capacity, features, and number of input and output channels—and that's without considering even one tape deck or transport which would have to be used with the board.

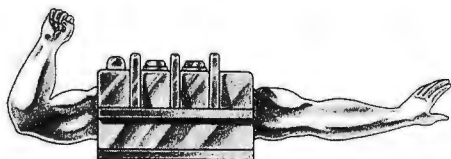
Surprisingly, not everyone who owns the kind of equipment we have been discussing aspires toward producing a "golden record." Many are just seasoned audio enthusiasts who want the kind of recording flexibility and professionalism afforded by this kind of gear. Perhaps all they will record are "off-the-line" tapings of their favorite FM programs or dubbings from their favorite discs. But with imagination and good equipment, they can bring to bear an involvement and creativity that makes it all worthwhile and changes high fidelity from a passive hobby into a very active and exciting pastime. ◇



*Dokorder's 7140 2/4 channel deck with "Multi-Sync."*



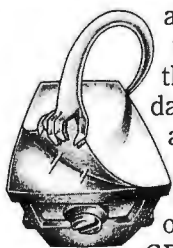
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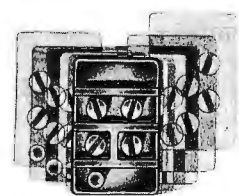
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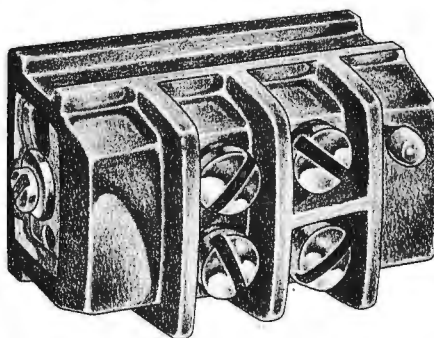
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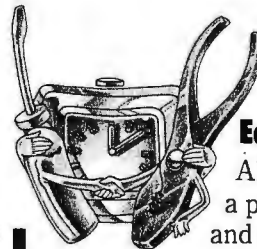
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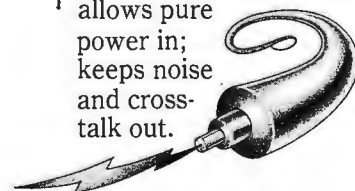
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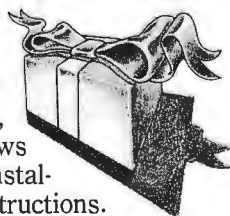


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# CHASING FOREIGN DX ON THE BROADCAST BAND

*Modest equipment and  
patience can be very  
rewarding on the BCB—  
especially with low sunspot activity.*

BY HARRY L. HELMS

**P**REDICTIONS point to a low level of sunspot activity in 1977. For SWL's and other users of the higher frequency shortwave bands, such news isn't very welcome. But if you enjoy searching for DX on the standard broadcast band, the lower level of solar activity means exciting opportunities for longhaul reception that is impossible in years of high sunspot activity.

Many SWL's got their start by DX'ing on the standard broadcast band (BCB) and then moved on to other bands. But if you are interested in tough DX—stations that are rarely heard and require skill and patience to tune in—the broadcast band can give you a challenge unsurpassed by any other range of frequencies.

You don't need a roomful of gear or a huge bankroll to hear some exciting DX. It's true that some BCB DX'ers have developed specialized loop antennas and such techniques as differential sideband detection to aid DX reception, while others have done outstanding research into radio-wave propagation on the BCB. But several DX'ers in the Eastern United States have reported reception from Europe and Latin America on portable receivers costing less than \$30. An excellent BCB DX listening setup can be purchased very inexpensively on the used-equipment market.

More important than your equipment is whether you have the attributes required of a successful DX'er. You need patience to wait for the DX openings, skill to exploit the openings, and a little bit of luck as well.

What you can hear depends greatly upon your location. Listeners on the East Coast have opportunities to hear

European, African, Middle Eastern, some Asian, and a few Pacific area stations. Listeners on the West Coast have chances for Asia, Australia, New Zealand, the Pacific Islands, and Alaska. Both coasts can hear Latin America and the Caribbean, although most agree that East Coast listeners have the edge over the West Coast in hearing the latter. Listeners in the Midwest have shots at everything from Australia and Asia to Africa and the Middle East, although reception from the various areas is often quite difficult. Several listeners on the East Coast have heard over 100 countries (the champ, Gordon Nelson of

Massachusetts, has heard over 130 countries) while expert West Coast listeners have country totals in the sixties.

It must be emphasized that, under proper conditions, all areas of the United States have a chance at any area from the west coast of Africa to Australia and east Asia. For example, 50-kW Australian BCB stations have made it to the Northeastern United States, while the 10-kW transmitter of Sierra Leone, located on the east coast of Africa, has been heard in California. Even Radio Peking's 1525-kHz station has been heard by several listeners on the East Coast. And now is a prime time to hear such DX, while the sunspot count is low.

## Bayerischer Rundfunk



*QSL from Bayerischer Rundfunk, 1586 kHz, is very colorful.*

**Propagation.** Years of low solar activity are conducive to long-haul BCB DX. The low sunspot numbers that wreck the higher shortwave frequencies reduce signal absorption on BCB frequencies. Thus, more signal reaches the listener and less gets gobbled up by the ionosphere.

Most BCB DX'ers confine their listening to the autumn and winter months, typically from early September to early April. Summer months are characterized by high noise levels and low signal levels that are due to increased ionospheric absorption produced by the longer days. Some advanced listeners have discovered that summer is a prime listening time for certain African stations that are covered up by European stations in winter. We will not concern ourselves with such advanced and difficult DX here.

For the past few years, October has yielded some of the best DX heard during the entire DX season. The months of December and January, favored by



those who look for domestic DX on the BCB, often produce mediocre DX conditions for foreign DX. The reasons behind this so-called "Midwinter Anomaly" have been researched by the National Radio Club. The NRC has a series of reprints available on this and other propagation topics.

Standard time and frequency station WWV can provide BCB DX'ers with valuable clues as to probable reception conditions for BCB DX. This is because it transmits the "A index," a measurement of the influx of electrically charged particles into the upper atmosphere. A-index values of 20 or more are usually sufficient to disrupt long-haul DX along high-latitude paths, such as East Coast to Europe or West Coast to Japan. When A-index values go over 40, severely disturbed conditions result that blank out many North American stations and allow Latin American stations to the south to dominate many channels. Such conditions are often termed "auroral" by BCB DX'ers because auroral displays often accompany such conditions in the winter.

The A-index values are transmitted by WWV at 18 minutes after the hour. Many BCB DX'ers make it a habit to tune in daily to these announcements during the DX season and keep a record of the daily values. When two or more consecutive days of low values (10 or less) are noted, odds are good that long-haul DX will be possible. When values are high, conditions for reception of Latin American stations will usually be excellent. There are exceptions to these rules, however, and the seasoned DX'er knows there is no real substitute for listening for those elusive openings.

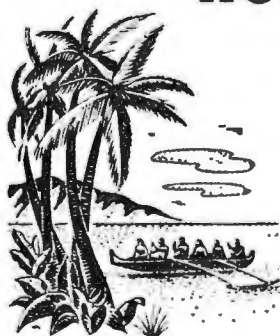
**Time to Listen.** Domestic BCB stations, even those that run 24-hour operations, usually sign off on Monday mornings after midnight for maintenance and tests. Thus, interference from American and Canadian broadcasters tends to be at a minimum on a Monday morning, starting at midnight Eastern local time. Unfortunately, a good opening to Europe or South America doesn't always fall on a Monday morning. So, those chasing foreign BCB DX often have to buck some heavy interference. Nevertheless, most BCB DX'ers try to listen every Monday morning, even during summer, since many stations in Latin America otherwise covered by domestic stations can be heard.

If you are tuning for stations in Latin America or the Caribbean, you can tune any time from shortly after your local



CSB2 Radio Clube Portugues, 1034 kHz, in Portugal, sends out this QSL.

## HONOLULU HAWAII USA



RADIO **KORL** on **650** KH  
**10** KW 24 HRS

CONFIRMS YOUR RECEPTION ON **10-6-75**

AT **2138/2240** HRS  
**HST**

ALAN L. ROYCROFT  
Chief Engineer  
*AKR*

Radio KORL, 650 kHz, Honolulu, Hawaii, confirms reception with date and hour.

## YSS Radio Nacional de El Salvador

San Salvador, C. A.

QSL

FRECUENCIAS:

655 Kcs. Onda Larga.

5980 Kcs. BANDA de 49 mts.

9555 Kcs. BANDA de 31 mts.



YSS Radio Nacional de El Salvador, San Salvador, sent this QSL for 655-kHz reception.



## Radio BERMUDA



*This scenic QSL was received from Radio Bermuda, broadcasting on 1235 kHz.*

sunset until just prior to your local sunrise. (Note, however, that many Caribbean stations sign off before 0500 GMT.) Eastern listeners tuning for Europe or Africa can try before 0000 GMT because that is when most Europeans sign off. (Although there are some all-night operations.) A prime tuning time for these "Trans-Atlantic" stations is from 0500 to 0600 GMT, when many of these stations can be heard signing on. Reception of these stations lasts until approximately 0700 GMT, when sunrise in Europe and Africa ends chances for reception.

Tuning for Oceania and Asia tends to be a late-night affair for many DX'ers. Hawaii and other Pacific-area stations typically become audible from 0700 GMT onward during the autumn/winter

DX season. Australia, Japan, China, and similar Asian targets often fade in around 0900 GMT and remain possible until roughly 1300 GMT.

Keep in mind that the bulk of the signal path of a BCB station's signal must be in darkness for long-distance reception to occur. Thus, reception of European stations on the West Coast just prior to the 0000 GMT sign-off time for Europe just is not possible—nor can an East Coast listener hear Asian stations at 1200 GMT.

**Selecting Targets.** As a general rule, the listener just starting to chase foreign BCB DX should try his hand at logging Latin America. Year-round, more openings occur for Latin America than any other area. The signal levels

are better than other foreign DX, and less sophisticated equipment is required than for Trans-Atlantic or Trans-Pacific reception. Finally, most DX'ers find it easier to try to identify a Spanish-speaking station rather than one in Japanese or Polynesian.

Many stations from Latin America are evening regulars in the United States. Listeners in the East can often hear Cuba on 590, 600, 630, 640, and 690 kHz with Spanish programming. Listeners in the Central and Western states often hear Mexican stations, such as XEWA (540 kHz) and XEW (900 kHz) with Spanish-language programming. Some Mexican stations, however, program in English and run high power. West Coast listeners may already be quite familiar with XETRA-690 and XEPRS-1090, while Midwestern listeners may regularly tune in XEG-1050 and XERF-1570. These stations, although located in Mexico, program for an American listening audience.

Stations in Central America are the most commonly heard Latin sources after Mexico and Cuba. Colombia and Venezuela are the most commonly heard countries from South America. Many stations in the latter two nations operate all-night on Monday mornings and are widely heard with the lessened domestic interference.

In the United States and Canada, all BCB stations operate on an even 10-kHz channel plan, starting with 540, 550, 560 and so on, up to 1600 kHz. Such spacing is rigidly adhered to in the U.S. and Canada. Many stations in Latin America and the Caribbean operate between the evenly spaced domestic channels and are known as "split-channel" stations. Some of these splits are easily heard during the evening, such as Belize-834, Haiti-1035, and St.

*Westdeutscher Rundfunk, 1586 kHz, uses this more technical design.*





Kitts-1265. Eastern listeners frequently report Surinam-725 and Cayman Is.-1555 during the evening. A receiver with good selectivity helps in receiving "splits," although the potent signals of the more common splits make reception not too difficult even on simple receivers.

As mentioned earlier, when the WWV A-index exceeds 40, check for exceptional conditions to Latin America. From his location in the Southeast, this author finds that with such high A-index readings, many Northern clear-channel stations are completely wiped out, leaving many Latin American outlets dominant, just as if one were listening somewhere in Latin America!

**Trans-Atlantic Stations.** Unlike the 10-kHz channel spacing in North America, broadcasters in Europe and North Africa operate on channels spaced 9-kHz apart, with the BCB extending from 529 to 1602 kHz. This means that many European and African stations operate on split channels. Power levels of the European and African stations are much higher than the average domestic station in North America. For example, the maximum power permitted an American or Canadian BCB station is only 50 kW, whereas powers of several hundreds of kilowatts are quite common in Europe.



*QSL received from Swiss station on 1562 kHz.*



*Houses of Parliament and the Thames dominate the QSL from England's BBC on 1295 kHz.*

Such power, coupled with split frequencies, means that quite a few stations can cross the Atlantic with ease. The one drawback for the BCB DX'er is the rather weak modulation used by Trans-Atlantic stations. This means that the carriers from such stations will often be quite strong, but readable audio will be difficult to obtain.

Listeners located in the East generally agree that signals above 1500 kHz are heard much more often than signals lower in frequency. A good "beacon" for Trans-Atlantic reception is West Germany's Westdeutscher Rundfunk outlet on 1586 kHz. This station uses a whopping 800 kW and operates all night. It's heard at the author's southeastern location even when no other European BCB stations are being heard. If WDR isn't being heard, no other Trans-Atlantic station is likely to be heard. You can try for WDR after your local sunset until approximately 0700 GMT. Programming is generally pop music and German announcements.

Listeners located in the central and western parts of the United States often find reception of European and African stations best in the middle and lower ranges of the BCB. A good beacon for the lower frequencies is the 845-kHz outlet of Rome, which is an all-night operation like WDR. Look for news bulletins in various languages on the hour and half-hour with uninterrupted music between newscasts. This, too, should be possible from your local sunset until

0700 GMT. Quite often this station is louder on the East Coast than any domestic station on 840 and 850 kHz.

Signals from the Middle East follow the same signal path as European and African stations and listening techniques are similar. An exciting new catch for many BCB DX'ers has been Turkey's new outlet on 1016 kHz. This 1200-kW monster has enabled many listeners to hear a new country on the BCB. Check our list for other good possibilities from Trans-Atlantic reception.

**Trans-Pacific Reception.** West Coast listeners have the edge here, of course, although some signals manage to make it to the East. Transmitter powers here are, on the average, quite a bit lower than for the European stations and, therefore, provide a severe test for the Eastern listener. Modulation levels are good, though, and usually some audio will make it whenever the carrier can be detected. Channel spacing is a hodge-podge, with some stations using 10 kHz, 9 kHz, or their own unique system of spacing.

Alaska, believe it or not, is considered to be Trans-Pacific due to the way the signal is propagated. This state is almost impossible to receive now from the East Coast, but listeners in the Midwest and West have several targets to shoot for, with KYAK-650, KFAR-660 and KFQD-750 being most likely. The auroral shield absorbs a tremendous portion of the radio energy of Alaskan stations,



## USEFUL ADDRESSES

**National Radio Club**, membership center, Box 118, Poquonock, CN 06064. Established in 1933, publishes *DX News* 30 times a year, weekly during the autumn/winter DX season. Sample *DX News* and membership information can be obtained for 50¢. Publishes an extensive set of technical manuals and reprints from *DX News*, with a list available by sending self-addressed stamp envelope. Also publishes a detailed log of domestic stations and antenna patterns.

**International Radio Clubs of America**, Box 21462, Seattle, WA 98111. Established 1964, publishes *DX Monitor* 34 times a year, weekly during the DX season. Sample bulletin and membership details can be obtained for 50¢. Publishes the *IRCA Foreign Logs*, which are compilations of stations reported as heard by IRCA members to the foreign DX column in *DX Monitor*.

**Medium Wave Circle**, 7 The Avenue, York, YO3 6AS, England. Publishes *Medium Wave News*, detailing DX reception in the British Isles and Europe. Send three International Reply Coupons for information.

## HAWAIIAN HOPEFULS

kHz

- 650—**KORL**, Honolulu, Monday mornings after 0700 GMT with WSM off, may be WRM from HJJX in Bogota, Colombia along East Coast. Rock-and-roll format.
- 690—**KKUA**, Honolulu, Monday mornings from 0700 GMT until local dawn, very difficult in East, QRM from XETRA in West, rock and roll format.
- 830—**KIKI**, Honolulu, after 0700 GMT until local dawn but WCCO makes reception in East very difficult, rock and roll format.
- 1040—**KHVV**, Honolulu, Sunday mornings after WHO sign off at 0600 GMT until local sunrise, pop and middle-of-the-road format.
- 1350—**KIVM**, Lihue, Monday mornings from 0700 GMT to local sunrise, crowded channel but has been heard in New Jersey in recent years, rock and roll format.

## TRANS-ATLANTIC ATTRACTIONS

kHz

- 665—**Portugal**, Lisbon, an all-night operation possible from local sunset until approximately 0700 GMT. Pop instrumentals and vocals usually featured.
- 737—**Spain**, Barcelona, Radio Nacional de Espana, another all-night operation with varied programming.
- 764—**Senegal**, Dakar is often the easiest African at 0600 GMT sign-on with chants.
- 845—**Italy**, Rome, "Nocturne from Italy" features news bulletins on hour and half-hour and pop music, usually best station on the lower BCB frequencies.
- 854—**Spain**, Murcia, another all-night operation; be careful not to confuse with Peru.
- 1016—**West Germany**, Sudwestfunk, Mainz, all evening with German pops and announcements.
- 1016—**Turkey**, Istanbul, sign on 0200 GMT, Turkish music and female announcer until fade out around 0600 GMT. Signal often mixes with that of the West German.
- 1205—**France**, Bordeaux, after 0500 GMT with ethnic language programming, French after 0600 GMT.
- 1214—**England**, BBC, common wave channel with domestic service, pops and rock, usually 0600-0700 GMT.
- 1394—**Albania**, Radio Tirana, Tirana, foreign service, various languages, often well after 0530 GMT.
- 1403—**Guinea**, Conakry, from local sunset to 0700 in French and African languages.
- 1466—**Monaco**, Trans World Radio, Monte Carlo, sign-on 0445 GMT with religious programming.
- 1475—**Austria**, Vienna home service after 0500 GMT in German, pop music.
- 1538—**West Germany**, Deutschlandfunk, Mainflingen, after 0500 GMT in German, pop and light music.
- 1554—**France**, TeleDiffusion de France, Nice, after 0500 GMT with French talk and music. Usually second best high-frequency bet.
- 1562—**Switzerland**, SBC home service, Sarnen, sign-on 0500 GMT with German talk and music.
- 1586—**Germany**, Westdeutscher Rundfunk, GMT Langenberg, from local sunset to approximately 0700 GMT, German music and talk, by far the easiest Trans-Atlantic station for most DX'ers.

## LATIN AMERICAN AND CARIBBEAN POSSIBILITIES

kHz

- 540—**Mexico**, San Luis Potosi, XEWA, Spanish programming evenings.
- 550—**Cuba**, Pinar del Rio, Radio Rebelde, Spanish programs evenings, carries "La Voz de Cuba" program all night.
- 595—**Dominica**, Radio Dominica, Roseau, English until 0230 GMT sign-off with U.S. pops and standards, difficult from the West Coast.
- 600—**Cuba**, Holguin, Radio Rebelde, same time and programs as Cuba-550.
- 640—**Cuba**, Havana, Radio Liberacion, Spanish programming evenings and carries "La Voz de Cuba" all night.
- 655—**El Salvador**, San Salvador, YSS, Radio Nacional de El Salvador, Spanish programs with much classical music until 0445 GMT sign-off.
- 675—**Costa Rica**, Radio Sonora, San Jose, with usual Latin American programming, evenings and nights until past 0500 GMT.
- 725—**Surinam**, Stichting Radio Omroep Surinam, Paramaribo, evenings in English, Dutch, Hindi and other languages until 0330 GMT sign-off.
- 800—**Netherlands Antilles**, Trans World Radio, Bonaire, religious programs in various languages in early evenings.
- 825—**Costa Rica**, Radio Titania, San Jose, all night with lively Latin American programming.
- 834—**Belize**, Radio Belize, Belize City, Former British Honduras, now independent nation, mostly English until 0500 GMT sign-off, perhaps easiest split channel.
- 900—**Mexico**, Mexico City, XEW, same times and programming as XEWA-540.
- 1035—**Haiti**, 4VEH, Cap Haitien, religious programming, mostly English, until 0030 GMT sign-off. Second best split behind Belize-834.
- 1055—**Colombia**, La Voz del Centro, Espinal, all night with lively Spanish programming and commercials.
- 1200—**Venezuela**, Radio Tiempo, Caracas, YVOZ, Spanish programming with many identifications, time checks, and commercials, Monday mornings after WOAI sign-off at 0600 GMT.
- 1265—**St. Kitts**, Radio Paradise, St. Kitts, with English religious programming evenings until 0300 GMT sign-off.
- 1555—**Cayman Is.**, Radio Cayman, English program evenings until 0330 GMT.
- 1570—**Mexico**, XERF, Ciudad Acuna, English programming evenings.



## TRANS-PACIFIC POSSIBILITIES

kHz

- 655—**North Korea**, Pyongyang, Korean home service programs from approximately 1000–1300 GMT, perhaps easiest Trans-Pacific station; has been heard on East Coast.
- 750—**Japan**, Sapporo, JOIB, Japanese programming but sometimes has English lessons, 0930 GMT until KXL sign-on.
- 770—**Japan**, Akita, JOUB, Japanese programming but often has English lessons like Sapporo-750, 0930 to approximately 1300 GMT, KOB often presents severe problems.
- 830—**Japan**, Osaka, JOBB, same programming as 750 and 770 kHz with some English lessons, 1000 to approximately 1300 GMT, WCCO main source of interference.
- 835—**China**, Nanchang, Chinese domestic service with many shrill voices, and much martial music from 1000 to 1400 GMT.
- 844—**Gilbert Islands**, Tarawa, English and various Polynesian languages from 0700 to sign off around 1000 GMT. Was heard in New York City area in autumn 1975.
- 877—**North Korea**, Wonsan, Korean home service, same programming and times as 655 kHz, frequency often drifts.
- 1040—**China**, Shanghai, Chinese and Japanese programming, Sunday mornings with WHO off 1000–1300 GMT.
- 1525—**China**, Urumchi, Russian foreign service 2300–0000 GMT. Has been widely heard on East Coast but rarely on West Coast, due to darkness path from Urumchi to the East Coast over the North Pole.
- 1550—**Australia**, Queensland, 4QD, cultural programs of classical music, discussions, and news from 0900–1100 GMT. Main interference is from domestic stations, has been heard on East Coast.

## ATTEMPTABLE ALASKANS

kHz

- 560—**KYAK**, Anchorage, Monday mornings after 0700 GMT with WSM off, country and western music format.
- 660—**KFAR**, Fairbanks, Monday mornings with WNBC off until 0900 GMT sign-off, rock and roll format.
- 750—**KFQD**, Anchorage, Monday mornings with WSB and KXL off until 1000 GMT sign-off, pop and middle-of-the-road music format.

thus making this state a noteworthy DX catch even in the Pacific Northwest.

Hawaii is somewhat easier than Alaska to receive. The most commonly heard station is KORL-650, usually noted on Monday mornings after the sign-off of WSM in Nashville. Reception is best after 0700 GMT. The station uses a rock-music format. It is more difficult to receive in the East now that Emisoras Monserrate in Colombia operates all night on 650 kHz. Other Hawaiian possibilities are KKUA-690, KIKI-830, and KIVM-1350. Try for these after 0700 GMT. All have been heard on the East Coast, although interference from all-night stations often makes reception quite difficult.

Another catch reported on the East Coast is Tarawa (844 kHz), located in the Gilbert Islands southwest of Hawaii. Their 10-kW signal is most often heard after 0800 GMT, with native music and language for quite exotic listening.

Mainland China and Japan are the easiest Asian stations to receive from the West Coast, although reception is extremely rare farther east. Japanese stations most easily heard include those on 750, 770, and 830 kHz. China has easily heard powerhouses on 835 and 1040 kHz. North Korea is often heard on 655, 725, and 877 kHz, but the last frequency drifts a few kilohertz.

Australian stations operate on the 10-kHz spacing used by stateside stations. This provides problems for DX'ers because by the time many Australian stations start to fade in, many domestic stations are beginning to sign on. The most widely heard Australian station is 4QD, Emerald. Try for it on 1550 kHz after 0830 GMT. It was heard in Florida as recently as 1970 but is extremely difficult farther northeast. Listeners in the Midwest and along the West Coast should have more luck.

Listeners trying for Trans-Pacific stations should remember that signals traveling such long distances are subject to rather deep fades, even though they may be quite loud on peaks. Thus, spend a few minutes on the frequency of the station you wish to hear before tuning away.

**Receivers and Antennas.** Many BCB DX'ers use equipment that's several years old. One reason is that many manufacturers of receivers today don't make quality receivers that cover the BCB. Secondly, many receivers are designed for SSB reception, but BCB DX is concerned with the reception of AM signals.

Selectivity is a prime requirement of a BCB DX receiver. Older models that have a Q-multiplier, crystal filter, or mechanical filters are highly popular with BCB DX'ers. Receivers are often highly modified according to plans available from the two BCB DX clubs. Favorite receivers are often those used when amateurs used a great deal of AM phone. Examples of popular receivers available on the used equipment market are the Hammarlund Models HQ150 and HQ180. The Drake Model SPR-4 is a current receiver that has gained popularity among BCB DX'ers. Military surplus receivers, such as the Models SP600, R388 and R390, are also highly prized by BCB DX'ers.

The old reliable long-wire antenna is still used by many BCB DX'ers, but every serious listener now uses a loop antenna of some sort. A loop is a bidirectional antenna that responds best to signals along its plane and rejects stations at right angles to that plane. Thus, a loop offers a way to minimize interference. Thanks to preamplifiers, a loop can offer substantial gain over a long-wire antenna. Older loop models were of air-core design, often 3' (0.91 M) or longer per side. Modern ferrite-core loops are quite compact and offer high performance.

A variation of the long-wire is the Beverage, which should appeal to listeners who live in rural areas with a great deal of space. A Beverage is a straight wire measuring more than 1000' (304.8 M) in length, affording great gain and directivity. Plans for these are available from the two BCB DX clubs.

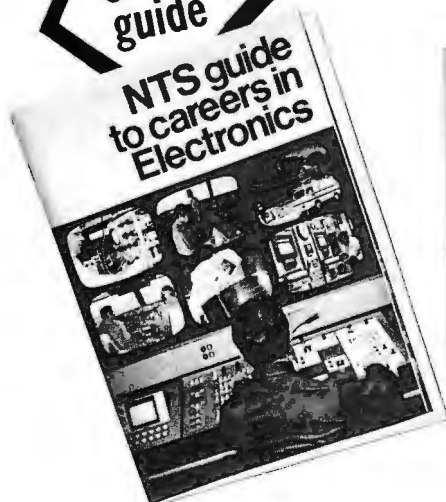
**Verifications.** Program detail for a BCB report should be greater than for a shortwave report. Commercials are the best material, along with announcers' names, slogans, jingles, program names, with song titles often being of little value (although they can seldom hurt). Do *not* use SINPO or other reporting codes; use only plain language. Use the native language and time of the station you heard, and always include return postage except when reporting to government-operated stations such as the BBC or an East European station.

**Now is the Time.** BCB DX opportunities must be taken advantage of when present—and the current low sunspot count provides an opportunity that won't be present again for some time. In addition, increasing numbers of all-night stations and the chance of greater power for American BCB outlets may severely curtail BCB DX in the future. ◇

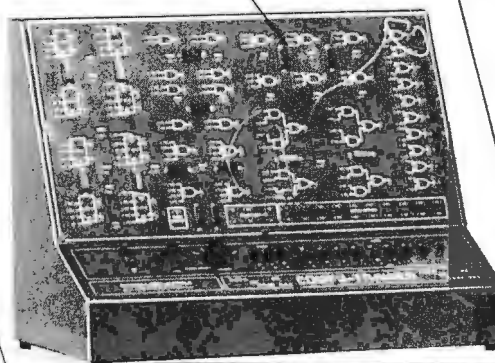


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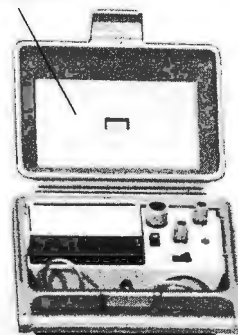


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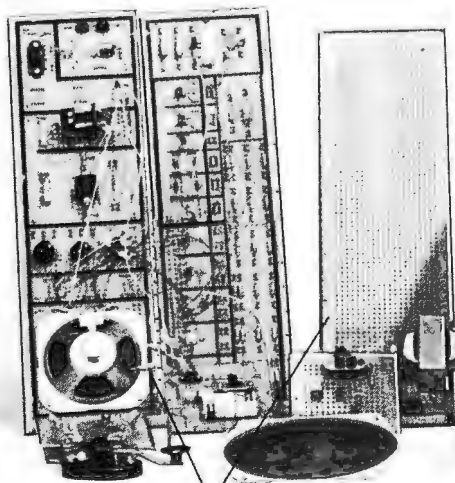


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# BUILD A STATE-OF-THE-ART BATTERY CHARGE MONITOR

*Prevents early failure of Ni-Cd batteries  
by determining proper time to recharge.*

BY W. J. PRUDHOMME

**T**HE PRIMARY cause of early cell failure in nickel-cadmium batteries is internal shorting that results from allowing the battery to become too deeply discharged in service. Therefore, any electronic device that uses Ni-Cd cells should contain a low-battery indicator that trips and warns you to recharge long before the battery's "critical" voltage is reached. Though there are a number of different types of charge monitors you can incorporate into your battery-powered equipment, the lambda-diode monitor described here is more advanced than other monitors in use.

Most low-battery indicators use a transistor to switch on the drive current for a LED or meter movement. The disadvantage here is that the monitor circuit places a constant drain on the battery, even when the LED is extinguished. In

low-power applications, this drain can drastically reduce the available operating time of the battery. The ideal solution is to use a circuit that draws no current from the battery as long as the supply voltage is greater than the critical potential of the battery. This is what the lambda-diode monitor does. In addition, the trip potential is adjustable over an 8-to-20-volt range, and cost is low.

**Technical Details.** The output potential of most batteries varies in relation to the state of charge. This relation is different for each type of battery. Lead-acid batteries, for example, exhibit an almost linear dropoff in output voltage as the cells become discharged. The same is generally true for dry cells. For Ni-Cd batteries, however, the dropoff is not quite linear.

A fully charged Ni-Cd cell has an output potential of typically 1.25 volts. The cell maintains an almost constant output potential until it is almost completely discharged, at which point, the potential drops rapidly to about 1.0 to 1.1 volts, or 1.05 volts average. A precise voltage monitor set to trip at this "critical" voltage level (or at a multiple of this potential if more than one cell is in series) can be very useful in determining the charge level of the battery.

An eight-cell Ni-Cd battery pack, for example, would have a fully charged output potential of 10.0 volts. When nearly completely discharged, the battery would have an output of 8.4 volts. If the lambda-diode monitor circuit shown in Fig. 1 were set to trip at 8.4 volts, we have a useful state-of-charge monitor for a Ni-Cd battery system.

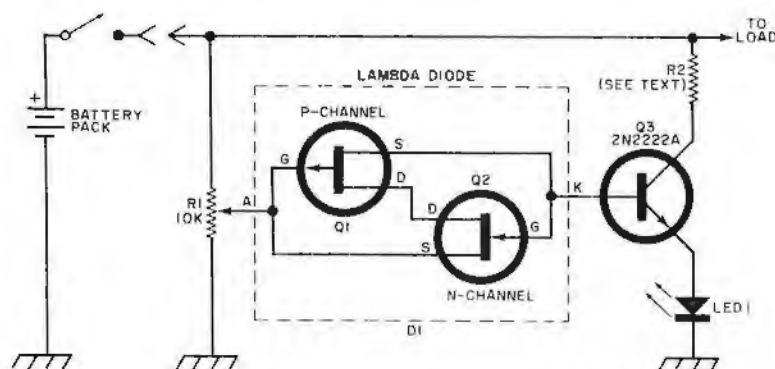


Fig. 1. Battery charger uses a lambda diode made of 2 FET's.

## PARTS LIST

- LED1—Any discrete light-emitting diode
- Q1—P-channel junction field-effect transistor (2N4360 or similar)
- Q2—N-channel junction field-effect transistor (2N3819 or similar)
- Q3—Silicon switching transistor (2N2222A or similar)
- R1—10,000-ohm, 1/5-watt miniature pc potentiometer
- R2—Current-limiting resistor (see text for details on how to calculate value; typically about 150 ohms, 1/2-watt)
- Misc.—Printed circuit board or perforated board and solder clips; relay (substitutes for LED1; see text); hookup wire; solder; etc.



The two-terminal, negative-resistance lambda diode shown inside the dashed box in Fig. 1 consists of one each n- and p-channel FET's. (There is no "lambda" diode available commercially.) Note that in this configuration there are only two terminals, which can be labelled "anode" (A) and "cathode" (K).

If the lambda diode is biased into cut-off, transistor Q3 is also cut off and LED1 is off. As battery voltage drops, a point is reached where the lambda diode abruptly conducts. This biases Q3 into conduction and turns on LED1 to indicate a low-battery condition. (The operating characteristic of the lambda diode is shown in Fig. 2.)

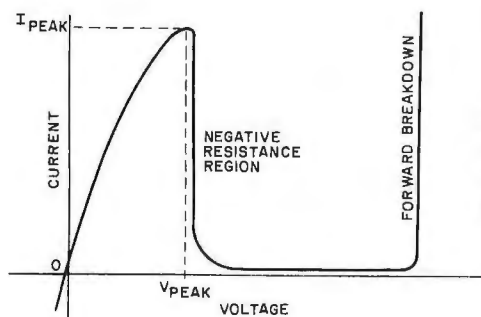


Fig. 2. Operating characteristics of the lambda-diode portion of circuit.

The potential at which the lambda diode conducts can be adjusted by potentiometer R1. Resistor R2 is a current limiter for LED1. Its value is determined by Ohm's Law ( $R2 = E/I$ , where R2 is in ohms, E is the potential of the battery at the point LED1 turns on, and I is the operating current of the LED used).

**Construction Details.** The lambda-diode battery-charge monitor is small enough to be built into the equipment in which a Ni-Cd battery pack is used for power. Alternatively, it can be assembled as an external low-battery indicator accessory and housed in a small utility box. In either case, printed-circuit (Fig.

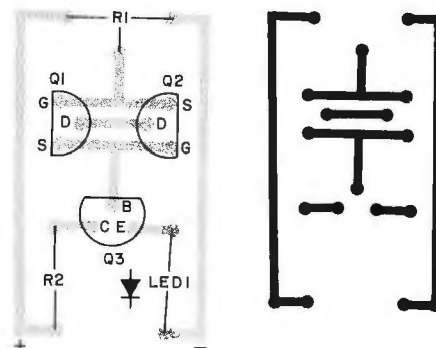


Fig. 3. Etching and drilling guide (right) with component layout (left) can be used or a perforated board will do.

3) or perforated board construction can be used.

The choice of JFET's for making up the lambda diode is not critical. Almost any combination of n- and p-channel devices will work as well as those specified in the Parts List.

You may want to consider substituting a small relay for LED1 to disconnect the battery pack from the load when the potential falls low enough to trigger the system. This setup will automatically protect the battery pack from polarity reversal during discharge. ◇

# How To Choose a Heat Sink

BY THOMAS ZWASKA

**T**HE purpose of using a heat sink for a power semiconductor device is to remove heat developed in the device so that the collector junction temperature remains below the maximum permitted—otherwise, the device may be damaged. To determine the proper heat sink for a given application it is necessary to find the maximum permissible thermal resistance from the collector junction to ambient air. The heat sink is then selected so that this maximum resistance is not exceeded. Here is a simple procedure to follow.

**Design Information.** The maximum power dissipated by a device is determined from:  $P_D = (T_J - T_A) / \theta_{JA}$ , where  $P_D$  is the maximum power dissipated by the device in watts,  $T_J$  is the maximum permissible junction temperature in °C,  $T_A$  is the maximum ambient temperature in °C, and  $\theta_{JA}$  is the thermal resistance from junction to ambient in °C/W.

Most power transistors have a maximum junction temperature specified of 200°C. Designing for a lower temperature, say 20% to 40% less, will increase device reliability and

life expectancy. The thermal resistance from junction to ambient is the sum of the individual thermal resistances: junction to case,  $\theta_{JC}$ ; case to heat sink,  $\theta_{CH}$ ; and heat sink to ambient,  $\theta_{HA}$ .

The thermal resistance from junction to case depends on the style of the case. Some common values are:

Case	$\theta_{JC}$
TO-3	1.5
TO-5	30.0
TO-66	4.0
TO-220	4.0

The thermal resistance from case to heat sink varies with the method of mounting. Factors involved include whether or not silicone grease is used, whether an electrical isolating washer is used, and the degree of mounting pressure used to hold the device to the heat sink. Here are some typical values:

Type of washer	$\theta_{CH}$	
	no grease	grease
none	0.2	0.1
beryllium oxide	0.4	0.2
anodized aluminum	0.5	0.3
mica	0.8	0.4

**Procedure:** Use the following steps: 1. Determine, by approximation, the maximum power dissipated by the device by multiplying the collector-emitter voltage times the collector current. For example, assume we have a series pass transistor in a voltage regulator whose output is 5 V at 2 A. The supply is 10 V, and the transistor is a 2N3055. Then the power dissipated is  $(10 - 5) \times 2 = 10$  watts.

2. Find  $T_J$  and  $\theta_{JC}$  from the device specification sheet. For the 2N3055,  $T_J$  is 200°C, but we will decrease this to 150°C. From the table above, for a TO-3 case,  $\theta_{JC}$  is 1.5.

3. Specify maximum ambient temperature. Assume 50°C.

4. Calculate maximum permissible  $\theta_{JA} = (T_J - T_A) / P_D = (150 - 50) / 10 = 10$  °C/W.

5. Determine  $\theta_{CA} = \theta_{JA} - \theta_{JC} = 10 - 1.5 = 8.5$  °C/W.

6. Determine  $\theta_{HS}$  from type of mounting. With a mica washing and using grease,  $\theta_{HS} = \theta_{CA} - \theta_{CH} = 8.5 - 0.4 = 8.1$  °C/W.

7. Select a heat sink having  $\theta$  equal to or less than this value. In our example, we could use a Thermalloy 6002 which has a  $\theta$  of 7.0°C/W. ◇

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# Experimenter's Corner

By Forrest M. Mims

## THE PHOTORESISTOR

**M**OST experimenters turn to junction semiconductors like phototransistors and photodiodes when it's necessary to design a circuit which responds to light. *Junctionless* semiconductor photoresistors composed of cadmium sulfide and cadmium selenide, however, also have lots of applications. This month, we'll look at several.

First, let's review some of the characteristics of junctionless photocells. Figure 1 shows the spectral response of typical photocells made from cadmium sulfide (CdS) and cadmium selenide (CdSe). The former has a peak sensitivity in the green part of the spectrum (515 nm), surprisingly close to the peak response of the human eye (555 nm). Cadmium selenide peaks at 735 nm, in the red part of the spectrum.

Both CdS and CdSe photocells are exceptionally sensitive to light. They respond by changing their resistance by a ratio of as much as 10,000 to 1! This means a cell which has a resistance of a megohm in the dark may have a resistance of only a hundred ohms in bright light.

The two biggest drawbacks of photocells are slow response time and susceptibility to fatigue. Phototransistors respond to a light pulse within microseconds and photodiodes within nanoseconds, but junctionless photoresistors require milliseconds or even seconds to respond to a light pulse. This, of course, means a CdS or CdSe photocell will ignore a brief flash of light a few microseconds long. Any phototransistor

will easily detect such a flash.

By fatigue (also known as the light memory or light history effect) we mean that the response of a particular photoresistor is governed to some extent by previous exposure to various light levels. This can be irritating, particularly if you're used to the more stable performance of phototransistors and photodiodes. When a photocell is used in a light meter, fatigue effects can be minimized by maintaining a reasonably constant light on the cell between measurements.

Now that we've covered some photoresistor basics, here are some practical applications you'll want to try.

**Simple Light Meter.** One of the most common applications for photoresistors is as sensing elements in light meters for photography. Figure 2 shows a simple light meter made from a CdS photoresistor, a 1-mA meter, and a low-voltage battery. Use any general-purpose CdS photocell with a high dark-to-light resistance ratio. You can connect the parts together with clip leads and have the circuit operating in a minute or two. But be sure the room lights are either off or very dim first. Otherwise the meter needle will swing over to its maximum

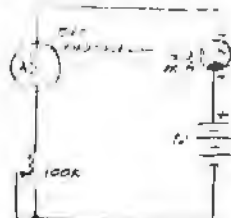


Fig. 2. Basic light meter.



Fig. 1. Spectral response of CdS and CdSe photoresistors.

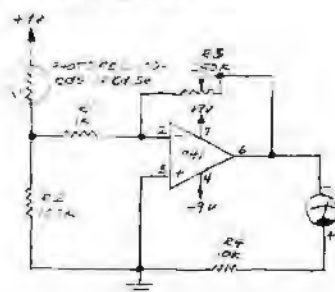


Fig. 3. Advanced light meter.



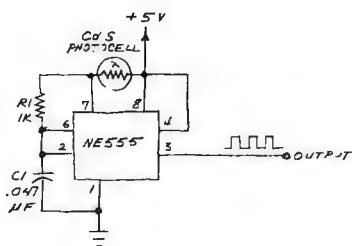


Fig. 4. A/D converter.

position and possibly be damaged.

After you connect the parts together, slowly point a flashlight beam toward the sensitive surface of the cell while watching the meter. As the meter needle responds to the changing light level, you'll gain a better appreciation of the sensitivity of the cell.

Incidentally, you can use a digital multimeter instead of a conventional meter if you prefer. This will eliminate the problem of accidentally slamming the meter movement and will also make reading the meter in the dark much easier. The digital readout, however, doesn't indicate changes as clearly as the moving needle of a conventional meter.

**Advanced Light Meter.** Figure 3 shows how to add an op amp to the simple light meter described above. The op

amp gives the circuit exceptional sensitivity and permits easy calibration by simply changing the value of feedback resistor  $R_3$ .

The circuit is so sensitive that it should be adjusted in the dark. Use a digital multimeter in place of the 1-mA meter or illuminate the meter scale with a "flashlight" made from a red LED in series with a 100-ohm resistor and a few 1.5-volt cells. Place the meter a foot or more away from the photocell to minimize the effect of light from the LED. Then turn off the lights and adjust  $R_3$  for a meter reading of zero. For an impressive demonstration of the circuit's sensitivity, strike a match while watching the meter.

**Analog/Digital Converter.** Analog/digital (A/D) converters transform analog signals such as voltage levels into patterns of pulses which can be used in a digital circuit. Figure 4 shows an ultra-simple A/D converter which transforms a variable light level into a stream of pulses. The circuit uses a 555 timer connected as a light-sensitive astable multivibrator. When the photoresistor is in darkness, the pulse rate is about 1 Hz; when it is placed near a 60-watt lamp, the pulse rate jumps above 22 kHz.

Incidentally, this circuit also makes a

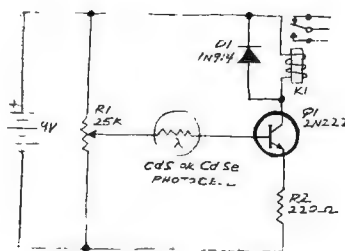


Fig. 5. Light-activated relay.

handy audio light meter. Just connect a small 8-ohm speaker in series with a 220-ohm resistor between pins 3 and 8 of the 555 IC. Then darken the room lights and play a flashlight beam across the photocell's sensitive face and listen to the variable audio tone produced.

**Light-Activated Relay.** Finally, Figure 5 shows a simple but effective light-activated relay which uses only half a dozen components. As light falling on the photoresistor increases in intensity,  $Q_1$  turns on and energizes the relay.  $D_1$  prevents any high-voltage kick created when the relay coil turns on and off from damaging  $Q_1$ . I used a 2N2222 for  $Q_1$ , but any general-purpose npn switching transistor will work. Resistor  $R_1$  serves as a voltage divider which sets the circuit's trigger point. ◇

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By John McVeigh

## TRANSFORMERLESS POWER SUPPLIES

**Q.** Do you have a circuit for a 12-to-14-volt, 3-ampere transformerless power supply? I want to use it to power an automotive AM/FM stereo radio indoors. I have tried several transformer types, but they are too noisy through the radio.—John Sumpolec, Jr., Las Vegas, NV.

**A.** The use of "transformerless" power supplies is very dangerous. If the line cord is inserted so that the "hot" side of the ac line is connected to the power supply "ground," accidental electrocution could result. If one portion of your body is grounded, and you touch the power supply ground (directly or, say, by touching the "grounded" chassis of the radio), you will be placing yourself directly across the ac line! Please do not use transformerless, line-powered circuits. I can think of no reason why transformerless supplies should be any "quieter" than transformer supplies. Perhaps the noise you mentioned was ac hum. If that is the case, the supply had insufficient filtering. Try beefing up the capacitance of the ripple filter by several hundred or a thousand microfarads or so. That should smooth out the rectified dc and "quiet" the supply.

## FINDING SUBSTITUTES

**Q.** In reading construction articles, I frequently come across parts descriptions including the phrase, "or equivalent." But I'm too inexperienced to decide when a component is equivalent to the printed type number. Are there any substitution sources?—John Whelan, Miami, FL.

**A.** There are a host of cross-reference works available at most electronics parts supply houses. Here are some examples: Motorola's HEP Cross-reference Guide and Catalog, and its Supplement No. 1; Sylvania's ECG Replacement Guide and Catalog; the RCA SK Series Replacement Guide; Radio Shack's Archer Semiconductor Reference Handbook; Howard W. Sams Co.'s Semiconductor Replacement Guide and its Transistor Substitution Handbook No. 14,

and Tab Books' Tower's International Transistor Selector.

Also useful are the Radio Shack Quick-Fill Catalog, and a distributor's catalog such as those by Allied Electronics and Newark Electronics.

## GUITAR PREAMP

**Q.** Do you have a circuit for a guitar preamp with active tone controls that would fit inside a guitar body? Also, I need plans for such devices as fuzz tone, phasers, wah-wah, and sustain.—Dennis Colarelli, Arvada, CO.

**A.** A phasor/flanger appeared in the June 1976 issue of POPULAR ELECTRONICS. For the other circuits, I would recommend "Electronic Projects for Musicians" by Craig Anderton. It's a 134-page (8½" × 11") soft-cover book, \$6.95, and is published by Guitar Player Productions, Box 615, Saratoga, CA 95070.

## USING AUTOPATCHES

**Q.** I have a question in reference to the article "Tie Into Ham Repeaters With This Low-Cost Autopatch" in the November 1976 issue. How can you check into a local repeater? Is this keyed out over a CB channel? Where can we get more information about autopatches and repeaters?—James Starr, Fort Wayne, IN.

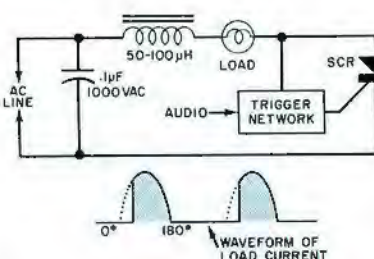
**A.** Repeaters and autopatches are not permitted on the Citizens Band Radio Service. The closest ham band that is open to repeater operation is the 10-Meter band. But this is a relatively recent development and I haven't heard any repeaters in the New York area. Most ham repeaters are located on the 2-Meter band (146-148 MHz), and some are on the 1¼-Meter (220-225 MHz) and ¾-Meter (420-450 MHz) bands, using the FM mode. If you're interested in learning about repeaters, consult "FM and Repeaters for the Radio Amateur" published by the American Radio Relay League, 225 Main Street, Newington, CT 06111. You might also check around Fort Wayne. I know that there's a re-

peater out there (on 146.16/76 MHz, I think), so there's probably a repeater club that maintains it. Club members can tell you all you want to know.

## SCR NOISE PROBLEMS

**Q.** I bought an inexpensive color organ about a year ago. It worked well until I put 150-watt floodlights on it. Now I have intolerable interference. Is there any circuit to attenuate the noise?—Michael Ethier, St. Paul, MN.

**A.** The color organ uses SCR's to turn on the lamps. When the SCR turns on, it does so abruptly, generating the fast-rising waveform shown in the figure. This waveform is repetitive and is rich in harmonic energy. The larger the overall amplitude becomes (as when you switched to higher-powered bulbs), the more harmonic energy is present. You don't mention whether the interference is coming through your audio system or through a radio receiver. It might be both—the harmonics in the SCR switching waveform extend into the r-f region.



You can prevent the radiation of harmonics by installing an LC network across the ac line, and, if necessary, shielding the color organ enclosure. The LC filter will prevent the transient from propagating out along the power wiring, and the shielding will prevent radiation by element leads and wiring within the organ. A commercial "brute force" line filter can be used, or a wound coil and capacitor can be installed inside the organ. A 1000-V ac, 0.1-µF disc ceramic capacitor and about 70 turns of insulated wire on a ferrite core are suitable. One mail-order source of ferrite rods is Amidon Associates, 12033 Otsego St., No. Hollywood, CA 91607. Its 30-61-4 (4" × 0.5" dia. or 10.2 × 1.3 cm) and 30-61-7 (7.5" × 0.5" dia. or 19.1 × 1.3 cm) rods, priced at \$2.50 and \$1.50 respectively, are well suited for use in "hash" filters.

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.



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noise phono stage . . . the sensitive dual-gate MOSFET tuner with PLL. Come by your nearby Radio Shack for a free copy of the reviews. And hear for yourself what all the excitement's about. You'll be amazed at just how far \$499.95\* can go. The Realistic 2000, 75 watts per channel, min. RMS at 8 ohms from 20-20,000 Hz, with no more than 0.25% total harmonic distortion.

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Controls are unusually flexible" High Fidelity Magazine, March 1977

The

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# Product Test Reports

## KRIS MODEL XL-50 40-CHANNEL CB MOBILE TRANSCEIVER

*Features exceptional noise-blanker and agc operation.*



**T**HE NEW Kris Model XL-50 AM mobile, finished in black with chrome trim and white labelling, employs phase-locked-loop (PLL) frequency synthesis, the "standard" scheme in 40-channel rigs. Channels are indicated by large LED displays that make identification much easier to read than from a selector dial.

Among the special features to be found in the Model XL-50 transceiver, which is Kris' top-of-the-line mobile, are: three easy-to-read illuminated meters (S UNITS, POWER, and MODULATION level); separate dimmer controls for the numeric display and meters; RF GAIN and TONE control; intercom (INT) provision; jack for external S-meter accessory; and a large illuminated RECEIVE/TRANSMIT indicator. Other features include: VOLUME, SQUELCH, and DELTA TUNE controls; noise-blanker (NB), PA, and INT/EXT speaker switches; external speaker jacks; detachable dynamic microphone; electronic voltage regulators; and negative- or positive-ground power source operation.

The transceiver measures 9.5"W × 8.9"D × 3"H (24.1 × 22.5 × 7.6 cm). Provided with microphone and mobile mounting hardware, it's priced at \$259.95.

**Details and Performance.** The double-conversion receiver section produces i-f's at 10,695 and 455 kHz. Ex-

cept for an IC in the PLL system and another IC in the audio section, bipolar transistors are used throughout the receiver. As is usual, the r-f stage is diode protected and has single tuned input and output circuits. A double-tuned bandpass circuit couples the two mixers together to aid in the suppression of unwanted signals.

The performance of the front-end section of the receiver yielded a sensitivity of 0.5  $\mu$ V for 10 dB (S+N)/N at 30% modulation with a 1000-Hz test signal. Image rejection measured 60 dB, i-f signal rejection was 70 dB, and other spurious signal rejection was between 45 and 60 dB. The latter was mostly due to overload "crossover birdies" in the area of the CB range.

Two ceramic filters are employed in the receiver, one at the input and the other at the output of the first 455-kHz i-f amplifier. This provides excellent selectivity. We measured a minimum of 60 dB rejection in adjacent-channel, desensitization, and cross-modulation tests. The overall 6-dB frequency response, including that of the audio system, was nominally 225 to 2450 Hz with the TONE control set to its midpoint. At the minimum and maximum settings, the response was 225 to 2000 Hz and 325 to 2800 Hz, respectively.

The audio section consists of a transistor squelch gate and an IC that contains the output amplifier that also dou-

bles as the transmitter modulator. Maximum sine-wave output at the onset of clipping with a 1000-Hz test tone and an 8-ohm load was 3 watts at 1.4% THD (4% at 400 Hz) on receive and PA.

Amplified squelch and agc are employed. Squelch threshold range was 0.2 to 1000  $\mu$ V. The agc was exceptionally flat, even at low signal levels. It held the audio output to within 1 dB with an r-f input change of 0.5 to 5  $\mu$ V (20 dB), to 1.5 dB at 1 to 10  $\mu$ V (20 dB), and to 3 dB at 1 to 10,000  $\mu$ V (80 dB). The S meter indicated S9 with a nominal 50- $\mu$ V signal. Meter readings dropped quite rapidly at lower r-f levels, requiring about 8  $\mu$ V to produce any indication whatever.

The noise blanker employs three pulse amplifiers. It interrupts the output of the second mixer during each noise pulse. (It is switched in and out in conjunction with an audio noise limiter.) The overall combination provides outstanding impulse-noise attenuation, making it possible to "read" a 0.25- $\mu$ V signal unhindered by noise pulses 100 dB above 1  $\mu$ V/megahertz bandwidth.

The PLL system utilizes a second conversion crystal oscillator (10,240 kHz) from which the standard reference is also obtained by means of the PLL divider. The voltage-controlled oscillator (vco) functions as the first-conversion oscillator and operates in the range of 37 MHz. Its comparison signal is derived by a "down" mixer in conjunction with a 35.47-MHz crystal oscillator to create a nominal 2-MHz signal in the PLL divider. The divider is in an IC that apparently also contains the control voltage circuitry for the vco.

On transmit, the vco's output is combined with a 10,695-kHz crystal-controlled signal at the transmitter mixer. The mixer is followed by a bandpass filter, predriver, driver, and power-amplifier stages. The output is matched to 50-ohm lines with the usual double-section network where harmonic attenuation is augmented by a TVI filter. Antenna switching is accomplished with a relay.

Powering the transceiver from a 13.8-volt dc source, the carrier output measured 4 watts into a 50-ohm dummy load.

An automatic-modulation control (amc) system is derived from the second microphone preamplifier (there are two mike preamps) and consists of three cascaded compression amplifiers that control the collector-to-emitter resistance of a transistor that is shunted across the input to the first mike preamp, thus serving as an automatic volume control. It performed excellently.



With a 1000-Hz test tone and mike input levels 16 to 26 dB greater than that required for 50% modulation, positive-peak modulation went to just 100% and 90% to 95% on the negative peaks. The maximum 1000-Hz THD was 2.6% (6.25% at 400 Hz and 75% modulation). With dynamic operation and maximum voice levels, producing high average modulation, the negative-peak modulation occasionally exceeded 100% for an insignificant duration and to an insignificant degree. Adjacent-channel splatter, at more than  $\pm 5000$  Hz from the carrier, was at least 60 dB down. The same was true in our tests with 1000- and 2500-Hz test tones.

The overall response of the transmitter, referred to 1000 Hz, was -6, +1, -6, and -10 dB at 300, 750, 1800, and 2500 Hz, respectively. The transmitter frequency tolerance was within 2 Hz of +50 Hz on any channel.

**User Comment.** The Kris XL-50, the first of a series of 40-channel rigs reported upon here, easily met the new FCC

requirements. Furthermore, its r-f power output and modulation capability were as high as the FCC permits, which is the same maximum as in the 23-channel days.

Particularly impressive was the XL-50's noise-blanker operation in the face of high impulse noise. In a mobile situation, this will be translated into reading more weak signals than with many other types of NB circuits. Also high on the performance list is the exceptional agc operation, which maintains a constant audio output level (to the ear) in spite of gross signal-level changes. When one adds fine selectivity, improved adjacent-channel splatter, et al, we have an excellent example of how newly designed 40-channel transceivers are capable of providing superior performance to the older 23-channel rigs.

As Kris's premium mobile rig, there are convenience extras that are most welcome (and, of course, added to the selling price). The meters are easy to read under all conditions, while the mod-

ulation meter gives curious CB'ers an opportunity to approximate the amount of modulation (calibrated at the 50% and 100% points) they're putting out. This contrasts well to the more common indicator lamp that's really nothing but a peak modulation indicator. Also, the selector dial includes the channel numbers so that, in the unlikely event the LED numeric indicators should fail, the operator will still know which channel he's clicked into.

To conserve space, most of the rotary controls are concentric pairs to provide dual functions. Though we can appreciate the need for this on a trade-off basis, we don't particularly care for the idea. Other fillips include a speaker mounting location on the left side of the rig's enclosure that enhances voice intelligibility, the letters "PA" displayed on the numeric indicators when PA mode is activated and a RECEIVE indicator that glows green and a TRANSMIT indicator that glows red when the appropriate functions are used.

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## YAESU MODEL FRG-7 COMMUNICATION RECEIVER

*Moderately priced, 0.5-to-30-MHz receiver uses Wadley Loop design.*



ONE CAN count the number of moderately priced general-coverage communication receivers on the fingers of one hand. So a rather new entry, such as the Yaesu Model FRG-7, is most welcome. Its 0.5-to-30-MHz tuning range covers standard AM broadcast, mediumwave, shortwave, amateur radio, and CB bands.

Called the "Frog 7" by SWL'ers, it's a triple-conversion receiver that uses a Wadley Loop design to inexpensively cancel drift from the variable oscillator. The all solid-state unit operates on ac line power and on 12-V batteries.

Rated sensitivity is 0.7  $\mu$ V on SSB and CW and 2  $\mu$ V on AM for 10 dB (S + N) /N. Selectivity is rated at  $\pm 3$  kHz at -6 dB and  $\pm 7$  kHz at -50 dB. After warmup, receiver drift is claimed to be

less than 50 Hz in any 30-minute period. The maximum audio output power is specified at 2 watts into 4 ohms. Between 1.6 and 30 MHz, antenna impedance is stated at 50 ohms, while the broadcast band antenna input is a high impedance between 0.5 and 1.6 MHz.

The receiver has a carrying handle on the right side of its cabinet. It measures 13 $\frac{3}{4}$ "W  $\times$  11 $\frac{1}{4}$ "D  $\times$  6"H (24  $\times$  28.5  $\times$  15.3 cm) and weighs 15.4 lb (7 kg) without batteries. Price is \$299.

**General Description.** The main tuning dial covers a 1000-kHz range with calibration marks located at 10-kHz intervals. The band is selected by a smaller MHz knob and dial, the latter with index marks and numbers at integral megahertz intervals over the full range

of the receiver. Near the MHz knob is a small red LOCK indicator that extinguishes only when the MHz tuning is properly set. In operation, the readings of the MHz and main tuning dials are summed to obtain the frequency to which the receiver is tuned. Above the main tuning dial is a small signal-strength meter, and to the right of the control is a button that moves the dial index for calibration purposes.

The r-f amplifier is tuned by a separate PRESELECTOR control and dial that covers the full range of the receiver in four bands. The bands are selected by a BAND switch. The MODE switch has positions for USB/CW, LSB, AM, and AM/ANL (the last with built-in noise limiter). The ATT attenuator switch has a NOR center position for unattenuated signal reception and DX and LOCAL positions. The TONE switch, also a three-position affair, has NARROW, NOR, and LOW positions. In the NARROW position, the nominal frequency response is 400 to 2500 Hz, while in the LOW position, it is 250 to 1500 Hz.

Near the POWER switch is a separate LIGHT switch that turns on and off the dial and meter lights to conserve power when operating the receiver from batteries. In addition to its built-in ac power supply, the receiver has storage space for eight D cells that can be used for portable operation. Alternatively, the re-



Closeup of front-panel tuning controls including band selector, preselect setting, and MHz knob and dial. Main tuning dial covers 1000-kHz range. LOCK indicator goes out when MHz tuning is properly set.

ceiver can be powered from an external 12-volt dc source, such as a car battery. Any or all of the power sources can be connected to the receiver simultaneously. Receiver operation is automatically transferred to the various supplies with the ac power line taking priority, then the external dc source, and finally the internal battery system.

In addition to a PHONES jack on the front panel, there is a RECORD jack that carries the audio at a fixed level that is unaffected by the TONE switch or VOLUME control. Plugging into the PHONES jack silences the built-in speaker.

On the receiver's rear apron are spring-loaded clips for AM and short-wave wire antennas, ground, and muting. Grounding the last silences the receiver when transmitting. There is also a uhf coaxial connector for a shortwave antenna; it parallels the other SW connector. A socket is provided for connecting an external 12-volt dc power source.

There is also a phone jack for an external 4-ohm speaker. (Using an external speaker via this jack silences the receiver's speaker.)

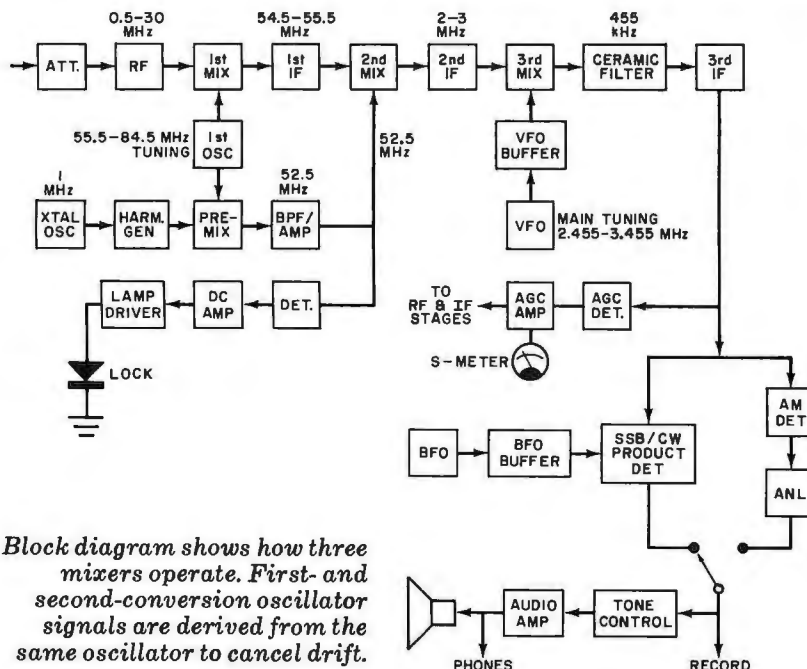
**Circuit Description.** From the antenna terminals and input attenuator, the incoming signal goes to one gate of a dual-gate MOSFET r-f amplifier (see block diagram). The signal then passes through a 35-MHz low-pass filter to the balanced first mixer, where it is heterodyned against a signal from the first conversion oscillator. This oscillator covers the range from 55.5 to 84.5 MHz, under control of the MHz dial. The output of the mixer is at the first i-f (54.5 to 55.5 MHz), where it is amplified by another dual-gate MOSFET. In the second mixer, an unbalanced circuit with a single FET, the signal is converted to a second i-f in the range of 2 to 3 MHz.

A novel feature is the manner in which the receiver's first- and second-conver-

sion oscillator signals are derived from the same oscillator, so that any drift in the two conversions is cancelled. In the block diagram, it can be seen that the first oscillator output is mixed with a "comb" of signals derived from a 1-MHz crystal oscillator and a harmonic generator at 1-MHz intervals. The output of the "premixer" where this combination takes place is passed through a 52.5-MHz filter that uses four double-tuned transformers. Only that frequency is allowed to reach the second mixer, where it converts the 54.5-to-55.5-MHz first i-f to 2 to 3 MHz. As the first oscillator is tuned from 55.5 to 84.5 MHz, a 52.5-MHz signal passes through the filter to the second mixer at 1-MHz intervals. (The LOCK light extinguishes each time a 52.5-MHz signal appears to signify the system is functioning properly.)

Following the second mixer, the signal is further amplified by a dual gate MOSFET and converted to 455 kHz in a third FET mixer. The local oscillator for this conversion has a 2.455-to-3.455-MHz range and is highly stable and under the control of the main tuning dial. After passing through a 455-kHz ceramic filter and two stages of amplification, the signal is converted to audio in one of the two detectors. For SSB and CW, a four-diode balanced modulator is used as a product detector. The frequency of the bfo, which is used for this final conversion, is shifted by the MODE switch for USB or LSB reception. For AM reception, a simple half-wave diode detector is used. An IC audio amplifier drives the speaker or headphones. The automatic noise limiter (anl), which functions only on AM, is a diode-shunt type. A separate agc rectifier measures the signal level at the output of the 455-kHz i-f amplifier, and the resulting dc voltage is amplified and used to control the gain of the MOSFET r-f and i-f amplifiers and the deflection of the signal meter.

**Laboratory Measurements.** The sensitivity of the receiver was measured at 2, 7, 14, and 28 MHz. It was exceptionally uniform over the entire frequency range, measuring between 0.9 and 1.1  $\mu\text{V}$  for a 10-dB (S+N)/N ratio on SSB or CW, and from 2 to 3  $\mu\text{V}$  on AM (using a carrier modulated 30% at 400 Hz). Selectivity was measured indirectly, by sweeping the frequency of the audio signal modulating our signal generator and plotting the receiver's audio output on a synchronized chart recorder. Although this includes the effect of any audio response shaping, it also shows quite clearly how the ceramic i-f filter



Block diagram shows how three mixers operate. First- and second-conversion oscillator signals are derived from the same oscillator to cancel drift.



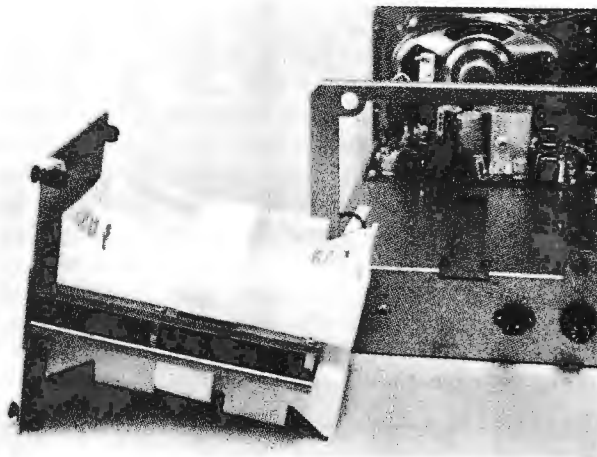
cuts off the higher modulation sideband frequencies.

With the TONE switch at its normal setting, the response measured at the PHONES output was within  $\pm 2$  dB from 20 to 1000 Hz (down 6 dB at about 1500 Hz). There was an abrupt drop in output above 3500 Hz, where the filter skirts begin to have an effect. With the NARROW switch setting, the response peaked broadly in the 500-to-1000-Hz range and was down 6 dB at 125 and 1900 Hz. In the LOW position, the response was fairly similar to NORMAL up to about 400 Hz; but it fell off rapidly to -6 dB at 900 Hz and -12 dB at 1500 Hz. At the RECORD output, the NORMAL response was flatter and presumably reflected the i-f response more accurately. It was down 6 dB at 2700 Hz and dropped much more rapidly above 3200 Hz. It should be noted that these measurements were made in the AM mode. In SSB, the effective audio bandwidth would be considerably greater, since the single sideband would be able to occupy most of the filter bandwidth, shared between the two sidebands in AM reception.

The antenna attenuator reduced signal levels by 10 dB in the DX position and by 20 dB in the LOCAL position. The S meter gave readings that bore little relation to the relative strengths of the signals. At 2 MHz, a  $0.5\text{-}\mu\text{V}$  input gave a meter reading of S3,  $0.8\text{-}\mu\text{V}$  gave S6, and only  $1.1\text{-}\mu\text{V}$ , the level that also gave a 10-dB (S+N)/N reading, drove the meter to S9. The same generosity was evident at higher levels, with  $1.7\text{-}\mu\text{V}$  yielding S9 + 10 dB,  $9\text{-}\mu\text{V}$  equal to S9 + 20 dB, and  $75\text{-}\mu\text{V}$  (which on most amateur receivers would be slightly more than S9) pushed the meter to an impressive S9 + 30 dB. Much of the time, the normal background atmospheric noise drove the meter to an S9 reading in the absence of a signal.

A triple conversion receiver is inherently subject to spurious responses, unless extraordinary precautions are taken in shielding and filtering. (Compensating for this is the fact that, due to its high first i-f, the FRG-7 is relatively immune to image responses.) The synthesizer technique used in the receiver gives a definite signal at every megahertz interval, corresponding to 0 and 1000 on the main tuning dial. Fortunately, the signals are relatively weak and did not interfere with reception of WWV, for example. We also found a large number of weak "birdies" spaced about 140 kHz apart, principally in the 26-to-30-MHz range. Although audible with no antenna con-

*Photo of the Yaesu receiver with the battery holder removed from case.*



nected, they were too weak to interfere with normal reception. However, at lower frequencies we found several rather strong spurious signals, principally at 2730, 3240, and 22,370 kHz, with amplitudes registering from 10 to 30 dB over S9 on the receiver's meter.

We checked the degree to which the receiver was desensitized by strong signals out of its immediate passband. When the interfering signal was 50 kHz from the station being received, a  $1000\text{-}\mu\text{V}$  level produced an audible reduction in signal strength. At 100-kHz spacing, the required strength was  $5000\text{-}\mu\text{V}$ . A  $10,000\text{-}\mu\text{V}$  signal desensitized the receiver at any spacing from 150 to 1000 kHz. (We did not check this with a signal in an adjacent band.)

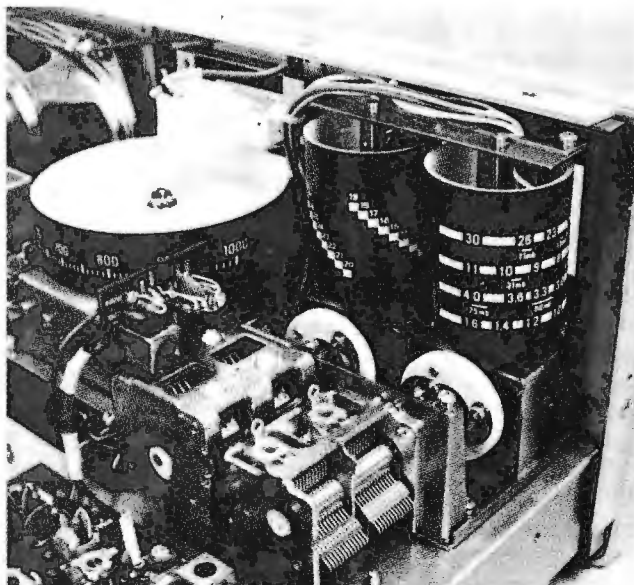
The dial calibration, when set against WWV at either end of the main tuning dial range, was accurate at the other end as well. Between these limits there was a slight calibration nonlinearity, evidenced by a 10-kHz error on CHU at 7335 kHz. Since the receiver lacks an internal crystal marker oscillator, there is

little that can be done about this, although it should not bother most short-wave listeners. Any frequency drift that might have occurred during operation was insignificant, and the receiver was fully usable from a cold start. The audio output was about 1.5 watts into 8 ohms and 1.7 watts into 4 ohms. If more distortion could have been tolerated, the rated 2-watt output could easily have been realized.

**User Comment.** For the SWL, this receiver offers an appealing combination of sensitivity, selectivity, accurate dial calibration, and modest price. It is easy to tune, and the quality of the sound was good.

The amateur operator will not be so well served. The ceramic i-f filter is too broad for today's crowded bands, either for CW or SSB reception. Moreover, if the receiver is located too close to a powerful transmitter, such as another amateur or a broadcast station, trouble might be experienced from desensitization. The 20-dB LOCAL attenuator will

*Rear view of preselector and MHz dials.*



help cope with this problem. Our test receiver's main tuning was free of backlash in the lower third of its range, but had a "rubbery" action toward the upper part of the scale that made tuning of SSB signals difficult. Unlike most communication receivers designed specifically for the amateur market, the FRG-7 does not give "single signal" reception of CW signals. Signals are audible at approximately the same level on both sides of zero beat, which effectively doubles the QRM level in reception. The agc is not defeatable and has a time con-

stant that we feel is too short for comfortable SSB reception, where it produced a disconcerting "pumping" of the background noise level.

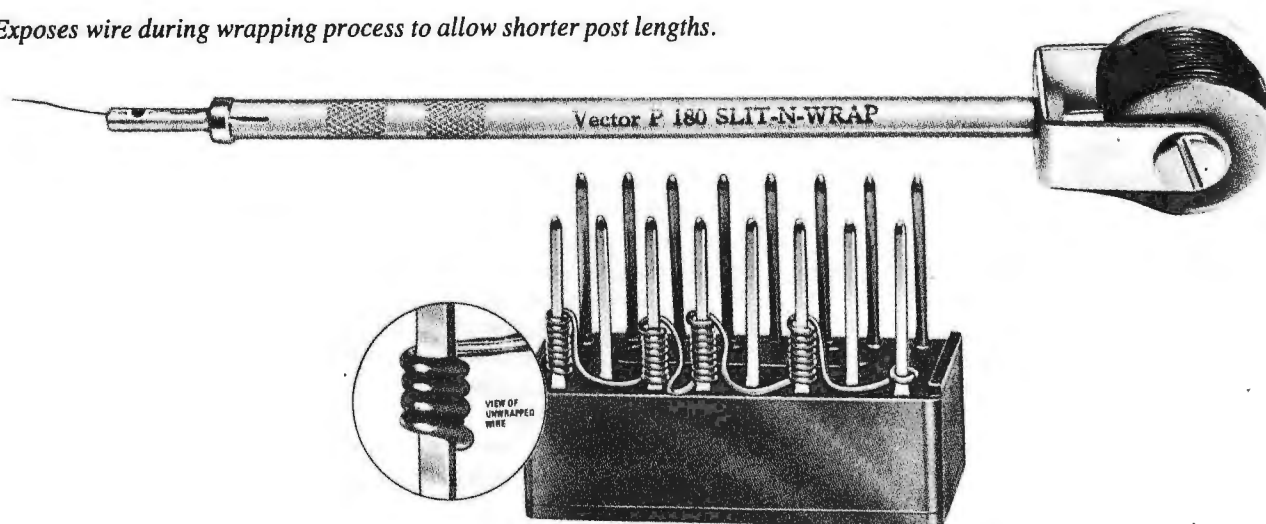
Useful extras for the SWL such as a noise blanker, notch control, switchable agc, crystal calibrator, etc. are absent. But they are not expected in this price range. Also, the "S" meter on our sample was useless as an indicator of incoming signal strength—every receivable signal registered better than S9, which is a handicap when seeking acknowledgement (QSL) cards.

Despite these criticisms, we found much to admire in the FRG-7. It is handsome, ruggedly built, on the whole very smooth-handling, and is rock-stable (even against pounding on the cabinet). SWL's who have attempted to use some of the lower-priced general-coverage superheterodyne receivers, plagued by drift, images, and useless calibrations, will be in for a pleasant surprise when they try this receiver. Considering what it offers, the Yaesu FRG-7 is a good value at its price.

CIRCLE NO. 104 ON FREE INFORMATION CARD

## VECTOR "SLIT-N-WRAP" WIRING TOOL

*Exposes wire during wrapping process to allow shorter post lengths.*



**T**HE POPULARITY of Wire Wrapping is growing by leaps and bounds, not only for original circuit prototyping but for final project wiring as well. The Wire Wrap technique is simple, fast, and reliable. Since it requires no soldering to assure electrically and mechanically sound joints, it readily lends itself to easy circuit modification. A number of Wire Wrapping tools have come on the experimenter/hobbyist market in recent months, one of which is the Vector "Slit-N-Wrap" tool.

Most Wire Wrapping tools require the wire to be cut to length and the insulation to be stripped away from both ends before wraps are made. What makes the Slit-N-Wrap tool different is that it eliminates these time-consuming requirements, thanks to a built-in slitting edge that exposes bare wire to the wrap posts during the wrapping operation. This slitting edge also makes it possible to make "daisy-chain" connections to a number of posts with a continuous, unbroken length of wire in wiring-pencil fashion. Hence, post length can be re-

duced to conserve space with the Slit-N-Wrap technique.

The Slit-N-Wrap tool is available in two models. The manual Model P180 tool that sells for \$24.50 comes with instructions, No. P183 forming tool, and two 100' (30.5-m) spools of 28-gauge wire. The cordless, battery-powered Model P160-4T comes with the Model P180 tool installed, two spools of wire, No. P183 forming tool, trickle charger, and instructions and sells for \$60.00. Replacement spools, each containing 100' of wire (with green, blue, red, or clear insulation), are available for three spools for \$2.75.

**General Details.** The Model P180 Slit-N-Wrap tool resembles a slender steel ballpoint pen with a small spool of wire at the top. The wire feeds from the spool, down through the hollow steel body of the tool, and exits through a hole in the tool's tip. The built-in slitting edge is located near the exit hole.

As the wire is wrapped around a wrap post, the slitting edge cuts through the

insulation so that bare wire contacts the post. The remainder of the insulation on the wire remains intact. No slitting occurs when the wire free-feeds through the hole, only when a wrapping operation is being performed.

The wire used with the tool is 28 gauge and has a thin but very tough insulation. Aside from being used for Wire Wrapping, it can also be tack soldered to copper traces on printed circuit boards or crimped around solder posts and lugs and soldered directly through the insulation. There is no need to strip away insulation to form a soldered joint; the insulation vaporizes when soldering heat is applied to it. The No. P183 forming tool and chisel knife that comes with the Slit-N-Wrap tool is used as a routing aid and for cutting wires close to the wrap pins and pc board traces.

**User Comment.** For our tests, we used the manual version of the Slit-N-Wrap tool. (The manual and battery-powered versions of the tool are identical except that the latter eliminates most



of the operator effort involved in wrapping.)

The first test to which we put the tool was in modifying our computer, which gave us an opportunity to test both the wrap and unwrap functions of the tool. We found the Slit-N-Wrap tool to be as easy to use as any other Wire Wrapping tool we have used in the past when it came to simple two-post runs. The tool excelled on daisy-chain runs and reduced what would ordinarily have been hours of cut, strip, and wrap to slightly more than a half hour of work. All our wrap connections were "perfect." What is equally important is that all our unwraps were accomplished without difficulty and left us with wire ends that could be wrapped like new.

Next, we decided to see if we could verify Vector's claim that the typical post-to-wire contact resistance was approximately 3 milliohms (0.003 ohm). To do this, we made up three daisy chains, each consisting of 10 wraps in series. Then, after nulling out the resistance of the test leads on our high-accuracy, laboratory-grade digital multimeter, we measured the total resistance of each daisy chain. Our readings of 0.0301, 0.0307, and 0.0308 ohm, when divided by 10 to obtain the average single-contact resistance, tallied very closely with Vector's claim.

In our tests for tack soldering the wire to pc traces and solder lugs directly through its insulation we noted that 27½-watt heating elements tended to char the insulation instead of vaporizing it. However, when we switched to the 37½-watt heating element we normally use in our soldering iron, the insulation almost instantly vaporized and allowed us to make excellent soldered connections.

For a final test, we selected ten of the wraps we had made for our resistance test setup and unwrapped and closely inspected the slitted wire under a magnifying glass. In all cases, the slits were neat and clean. The insulation had parted neatly during the wrapping operation, as evidenced by the clean and well-defined "bites" in the wire from the posts.

Our experience with the Vector Slit-N-Wrap wiring system has made us a firm believer in this new tool. We would not hesitate to recommend the tool to anyone, amateur experimenter or professional technician or engineer, who does a lot of project building, prototyping, and circuit modification. It will pay for itself in time saved and frustration avoided.

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2. Kodak Ektalite screen (recommended because it is 16 TIMES BRIGHTER than a flat matte surface and 6 TIMES BRIGHTER than most flat beaded movie screens) is the same used by major big screen television manufacturers. The Ektalite screen is made of a special treated sheeting laminated to a spherically curved "shell" frame. The Ektalite screen dramatically out-performs all other types of screens by reflecting all its incident light back to the viewer instead of absorbing it. Its parabolic shape rejects extraneous light, thereby concentrating a highly efficient and directionally selective television image that is exceptionally sharp and colorful.

3. Can be used with or without remote control television because the control panel is faced toward you like any conventional television.

4. This system will reproduce whatever signals it receives. We therefore do not recommend it in poor reception areas. The distortion would be enlarged.

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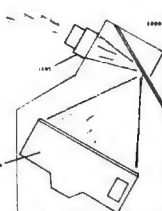
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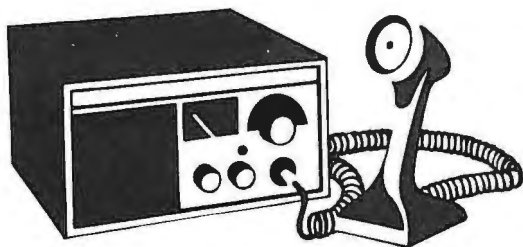
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CIRCLE NO. 24 ON FREE INFORMATION CARD



# CB Scene

By Ray Newhall, KWI6010

## CB-RELATED TVI—AND WHAT TO DO ABOUT IT

**T**HE NEW FCC Rules make it the CB'er's responsibility to eliminate all television interference which results from transceiver emissions outside the authorized frequencies (26.965 to 27.405 MHz). These Rules apply and are enforceable, even though the CB'er can prove that his rig conforms with the technical specifications set forth in the Rules at the time of manufacture.

All transmitters and receivers radiate some harmonic and other spurious emissions. How, then, can the CB'er meet this requirement and still continue to operate?

**Causes of TVI.** In only about 20% of reported TVI cases has the cause of the problem been in the CB rig or the operating habits of the CB'er. In these cases, nearly always the CB'er is operating his rig illegally—say, by overmodulating—or has inserted devices in his antenna lead which generate harmonic energies not present at the output of the CB rig itself. In any case, the CB'er should work with the complaining TV viewer to determine what remedies are needed and where they must be applied.

Once it has *positively* been established that the TVI occurs when a particular CB transmitter is in use, it must be determined which TV channels are affected when the CB push-to-talk switch is pressed. TVI caused by a CB signal will normally cause the picture to fade, or cause cross hatching or parallel

lines across the screen. (In no case can TVI which affects the TV audio be attributed to the CB transceiver.)

If the TVI appears on channel 2, or on both channels 2 and 5, but no others, there is a strong possibility that the CB station (the transmitter and its antenna system) is at fault. If the TVI appears on other channels as well, the television receiver is most likely the culprit. These rules will apply almost without exception. However, in an apartment or condominium where there is a common TV antenna system in use, the master distribution amplifier (if overloaded by the CB signal) can generate harmonics of the CB output. Seemingly, the CB transceiver is at fault. As a double-check, remove an affected TV receiver from the master system and connect it to an indoor antenna. If the TVI still appears only on channels 2 and 5, look to the CB rig for the cause.

**Harmonics.** TV channel 2 is located at about 54 MHz, which is just double the frequency of the 27-MHz CB. Almost every r-f generator (such as a CB transceiver) will produce signals at multiples of the primary oscillation frequency. But FCC Regulations impose strict limitations on the strength of harmonics radiated by the transceiver either through its cabinet or into the antenna line. If these harmonics pass beyond the reach of the rig's filters, there is *nothing* that can be done to suppress them at the TV

receiver. Those are the very frequencies that the receiver is designed to accept, and an attempt to reduce their strength at the receiver would merely result in a loss of the desired TV signal. Conversely, if the receiver cannot reject fundamental CB signals at 27 MHz, then there is nothing that can be done by the CB'er to eliminate the TVI. Unfortunately, some TV manufacturers do not include sufficient filtering to reduce the receiver's vulnerability to strong radio signals removed from the TV channel frequencies. In the past, legislation has been proposed in Congress to require TV manufacturers to include such filtering but the bills expire before any action is taken. In response to the growing RFI problem and the apparent need for minimum electromagnetic compatibility standards for home-entertainment devices, similar bills are expected to be introduced in this session of Congress.

**Remedies at the Receiver.** In most cases, the TV receiver's susceptibility to overload by CB signals can be compensated for without extensive modifications. There are commercially available high-pass filters which can be attached at the antenna terminals at the rear of the TV. They prevent the CB signal from reaching the TV tuner. In severe cases, the filter might have to be mounted inside the receiver cabinet at the tuner's antenna input.

Many TV manufacturers will provide such filters free of charge to their customers who experience TVI. Alternatively, they might provide information on how TVI may be eliminated.

**Remedies at the Rig.** In the case of harmonic interference, if the CB'er is using a type-accepted rig that has not been modified in any way, chances are that the problem lies between the transmitter antenna terminals and the antenna itself. If the CB'er is using an illegal "linear," there is a good chance that he

## REACT "Help" Flag

A special flag for motorists in distress is being distributed by local REACT CB teams. The REACT "Help" Flag is made of highly visible orange reflective vinyl, with the word "Help" and the REACT emblem printed in black. All CB'ers who see these flags on a disabled vehicle are asked to call their local REACT teams on Channel 9. The flag identifies a motorist in distress who wants assistance through CB radio. To obtain a flag, contact your local REACT team, who are distributing them as a combined community service and local fund-raising project, or send a donation of \$5.00 or more to REACT International, Inc., 111 E. Wacker Dr., Chicago, IL 60601.





is causing severe TVI to at least 95% of the TV receivers within ¼ mile of his station. But linears are not the only cause of TVI. Any device introduced into the antenna feedline between the transceiver and the antenna has the potential of introducing harmonic radiation not present at the transceiver. Some linear amplifiers can increase harmonics by as much as 9 dB even when turned off. Coaxial switches and SWR meters can also introduce harmonics which might cause TVI. Any poor or corroded connections in the transmission line or at the antenna itself can cause TVI.

The CB'er with a TVI problem should first go to work on his antenna system, checking the SWR with a reflectometer. If the antenna system is at fault, it should exhibit an SWR of 3:1 or more. Make sure that the antenna lead shield is grounded at both ends and that all connections are clean and solid. Check the dc resistance to see that it is very low (4 ohms or less). Be certain that the coaxial cable is high-quality RG-58/U or RG-8/U, and that its outer vinyl jacket has not deteriorated. Examine the antenna for corrosion. If necessary, clean and weatherproof all connections and hardware.

If the antenna and feedline check out OK, and the TVI is still present, the CB'er should suspect the rig itself. Take it to a qualified, licensed technician for a thorough examination. Installation of a low-pass filter at the transceiver output can suppress any internally generated harmonics.

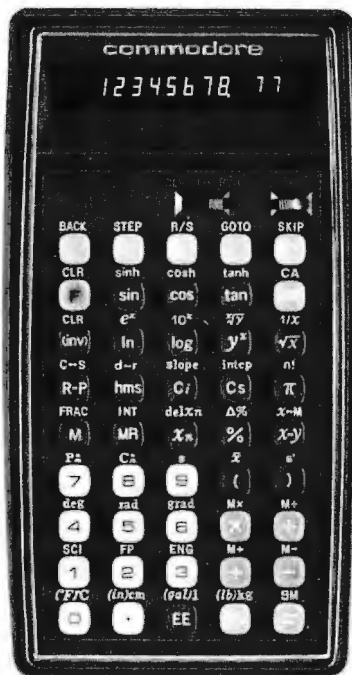
Two of the top enforcement priorities of the FCC are to locate and confiscate overpowered, illegal transmitters, and to reduce CB-caused TVI. They know that wherever there is a concentration of TVI complaints, they can probably fulfill both priorities at once. You can be reasonably certain that, sooner, or later, there will be an undercover RDF vehicle on the block.

For a free information kit on TVI, send a stamped, self-addressed envelope to Box 21, Hartford, CT 06103.

**More About TVI Filters.** The PULAC Task Group on Local Interference is currently conducting laboratory tests on all types of TVI filters. Preliminary tests have shown some to be very effective in controlling TVI, while others are nearly useless. This group is currently compiling a list of commercially available filters which meet its approval criteria. All filter manufacturers are invited to submit samples of their products for testing by the FCC-sponsored group. ◇

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- FUNCTIONS OF X - 1/x, X
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Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

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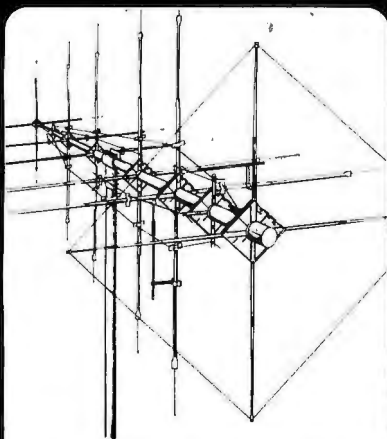
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## MAC'S SERVICE SHOP

## Basic and New Soldering Techniques

BY JOHN T. FRYE

**B**ARNEY was working on a small pc board, his brow wrinkled in concentration. He was vainly trying to unsolder a transistor from the board without burning another component or creating solder bridges.

"Here," Mac said, handing him a slender gray-cased object with a red slide switch on the top and a short metallic rod protruding from the end. "Try this."

"What's this?" Barney asked suspiciously. "It looks like it might suck eggs."

"It's Weller's Model WC100 cordless soldering iron, one of a breed of portable irons introduced by a few manufacturers. It weighs 5¾ ounces and is only 6¾ in. long without the interchangeable tip. Four tips are available; a regular, a fine point (which is in there now), a long reach, and a miniature which has an extra fine point. The tips, less than 1/5" in diameter, are made of nickel-plated copper. Each is ceramic-cemented to a stainless-steel tube that is Teflon-insulated inside and serves as a concentric path for current to the tip. These sturdy stainless-steel shanks also give the tips a degree of rigidity to inhibit bending during soldering.

"The WC100 comes with a wall-socket charger to keep its NiCd batteries charged. The cord from the charger plugs into a jack on the rear of the iron. Weller says that completely discharged batteries can be recharged in 14 hours, after which 50 to 100 pc board connections can be made before another recharging. For bench work, the charger

can be connected continuously without over-charging or shortening battery life."

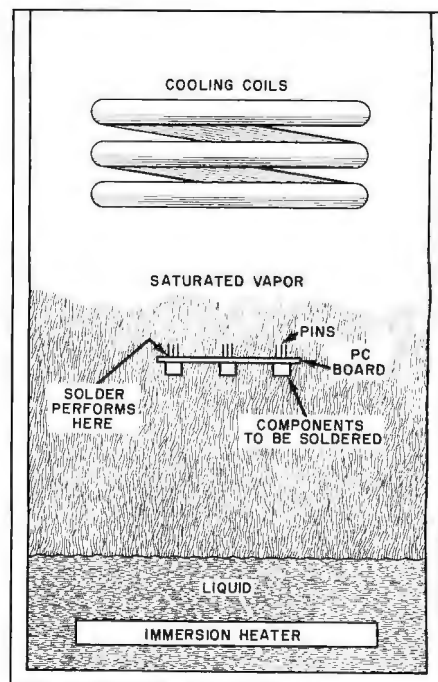
While Mac was talking, Barney had easily unsoldered the transistor. The tiny tip and the built-in worklight just below the tip shank made it easy to put the heat precisely where it was needed.

"Hey, this little rascal has plenty of oomph!" Barney exclaimed.

"That's right. It starts melting solder in six seconds and attains a tip temperature of 700°F (370°C) which is almost twice the temperature needed to melt 60/40 solder."

"Do you think it will replace our conventional irons and solder guns?"

"No, but it will supplement them. Just as we have a wide array of screwdrivers for different jobs, we also need several different soldering tools to work on today's electronic equipment. The important feature of the battery-operated iron



*Mac's sketch of condensation soldering system shows how boiling liquid is heated to form saturated vapor. When the vapor condenses above, the latent heat of vaporization melts solder.*



is its portability. It's not tied to a wall socket so it can be used in a car, on top of a TV tower, or anywhere that ac line current is not available. Of course, it has limitations. It's specifically designed for pc boards, jewelry, or small-diameter wires. It is not capable of performing heavy-duty continuous soldering. A tip only a little larger than a match head doesn't store up much heat! Getting maximum efficiency out of this little iron calls for a sharpening up of our soldering techniques."

"How's that?"

"When we have a large surplus amount of heat available, as we do with a heavy-duty iron or a gun, we can get by with sloppy soldering procedures—insufficient cleaning of the joint, failure to keep the iron properly tinned, melting the solder on the iron instead of the heated joint, etc. By using far more heat than necessary, we are able to make a fair joint by brute force. This won't happen with the small battery-operated irons. When using them, we must make the most of every watt."

**The Right Way to Solder.** "For example, with the small irons, we use only high-quality 60/40 solder that has a flow temperature very close to the ideal 361°F (183°C) of the eutectic 63/37 tin-lead alloy. As the alloy moves away from this eutectic point, more and more heat is needed to transform the solid solder into a free-flowing liquid. Also, with small irons, we use 19- or 21-gauge small-diameter solder to insure that most of the heat from the tip goes to the joint instead of being heat-sunk into the roll of solder. Further, we will make sure every joint is really clean before soldering. If at all possible, we'll arrange things so the iron can be applied below the joint. In this way, convection currents will carry the heat up and over the joint. Finally, we'll observe the "Golden Rule" of solder: *Apply the flat face of the adequately heated soldering iron directly against the assembly and simultaneously apply the solder at the exact point of iron contact.*"

"What's wrong with melting the solder on the tip and transferring it to the joint?"

"To appreciate the error in this common procedure, you must understand the functions of the solder flux. The flux—usually an activated rosin—cleans off the solder-repelling oxide that forms on all metal surfaces, but it can only do so in its corrosive hot liquid state. When cool, rosin is chemically inert and has an electrical resistance in excess of 3300 trillion ohms per cubic inch. The flux's other function is to lower the surface ten-

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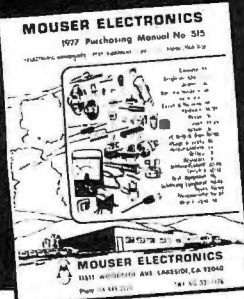
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sion of the liquid solder and make it flow over and through the joint. Properly fluxed solder will actually flow against gravity to penetrate a small crevice by capillary attraction.

"Keep in mind that making a solder connection is not just a matter of sticking two pieces of metal together with a kind of conducting glue. There is actually a complex chemical action taking place. After the melted flux has cleaned off the corrosion on the metal surfaces, the solder wets and penetrates these clean areas and actually dissolves very thin layers of the juxtaposed metals so that they form an alloy with the solder. They thus unite with each other as an alloy that is partially solder and partially the joined metals. Ideally, this alloyed layer is only 0.004 in. (0.1 mm) thick. Any solder added after this alloy has formed is both superfluous and wasteful.

"Now, let's get back to what's wrong with carrying the molten solder to the joint on the tip of the iron. The rosin core of the solder is very volatile. You can see it evaporating into blue smoke when you touch a hot iron to a piece of solder. When this happens, the flux has dissipated itself on the tip long before you reach the joint, so you have solder with no flux. The solder may surround the oxidized surfaces of the wires, but it cannot wet and penetrate them by itself. The result is a mechanically poor, high-resistance joint."

"OK, I'll follow the Golden Rule no matter what soldering instrument I use," Barney promised. "Manufacturers of electronic equipment must certainly go by the book. Considering how many of their solder joints we look at, it's amazing how few poor connections we find."

**Commercial Techniques.** "True. They've found that following sound soldering principles pays off. Of course, their mass-soldering methods are much different from those we use, especially with pc boards. We've talked about dip-soldering and wave-soldering before; but recently I read in Western Electric's *The Engineer* about some new and very intriguing methods of mass-soldering.

"One of these is solder fusing with forced convection liquid heating. One problem associated with pc boards is solder slivers. They result from the undercutting of electrode-deposited solder used as an etch resist during copper removal. Unless removed, they can short circuit pad layers in multilayer circuits. The slivers can be eliminated by raising the board temperature to about 410°F (210°C) and holding it there for about 30

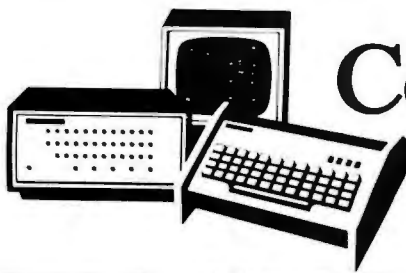
seconds. One way to do this is with radiant heat, but heating a multicircuit board uniformly without exposing heat-sensitive components to excessive heat is difficult. Heat shields can be used, but they are expensive. Forced convection heating with hot air is also used, but it requires longer exposure to heat and may also require baffles to protect low-mass areas from excessive temperatures. Immersing the board in a heated fluid, such as glycerol, avoids most problems encountered with the other two methods and provides excellent temperature control, but glycerol requires very careful handling.

"A new method, called condensation soldering, is now being used not only to eliminate solder slivers but also to perform 'reflow soldering.' In this procedure, rosin-coated solder preforms shaped like little doughnuts are placed over the tops of pins to be soldered to the plated-through holes in the pc board. When the temperature is raised sufficiently, the solder melts and flows along the pin through the plated hole and forms a solder fillet. If the temperature can be precisely controlled, the distance the solder travels along the pin can be easily adjusted—a factor to be considered when the protruding end of the pin will be connected in an automated Wire-Wrapping process. For a good connection of this type, which is common in telephone work, there must be no solder under the wrapped wire—which rules out wave or dip soldering.

"Condensation soldering is accomplished very easily. In simple terms, a tall, open-topped vessel contains a liquid, say fluorinated poloxypolyene, which is brought to its boiling point of 436°F (224°C) with immersion heaters. When a relatively cool object such as a pc board with solder preforms is placed in the saturated vapor, which rises to the top, the vapor condenses uniformly on the object, releasing the latent heat of vaporization. A very high heat transfer rate is associated with this phase change, so the heating process is quite rapid. In fact, 20,000 solder connections have been made simultaneously in 60 seconds with this contamination-free process."

"Wow," Barney said. "All I needed was a little help unsoldering that transistor, and I got an introduction to a new type of soldering iron, a refresher course in good soldering techniques, a lecture on the functions of solder flux and the real nature of a solder joint, and finally a description of some methods of mass soldering. That will do me for today." ◇





# Computer Bits

By Leslie Solomon

## SOME NEW HARDWARE AND SOFTWARE

**T**HE MARKETPLACE is so loaded with enticing material (hardware and software) for the computer hobbyist—with more being introduced all the time—it's getting so he hardly knows where to start. The "well-known" hobby computer manufacturers are doing their best to introduce new products on a regular basis; and many new firms are starting to spring up. Once the hobbyist gets things under way, however, there is enough equipment available for him to build up a really powerful personal computing system.

This month, let's take a look at some of the more recently introduced items that are available.

**Printers.** This seems to be an area of great interest to most hobbyists, as reasonably priced hard-copy devices are scarce. The Digital Group (Box 6528, Denver, CO 80206; Tel: 303-861-1686) has a kit for \$495 for an interface card and a printer that produces 120 characters per second, 96 characters per line, 12 characters per inch horizontally by 6 lines per inch. This printer can make up to four copies simultaneously. The character set and pitch are variable under software control and allow for double-width characters, different-width characters in the same line, etc. The printer uses a 5×7 matrix and the ribbon has built-in re-inkers for an expected life of 10-million characters. The paper is standard 8½" roll, fanfold, or cut page, and the system interfaces via an 8-bit parallel port.

**Video Displays.** If you have an Altair-bus system, take a look at the VB1 Video Board from Cybercom (Solid State Music, 2102A Walsh Ave., Santa Clara, CA 95050; Tel: 408-246-2707). This \$189.95 kit (\$269.95 assembled/tested) video board features cursor, video reverse and graphics under software control, a selection of either 32 or 64 characters per line, 16 lines, upper and lower case with Greek alphabet and

interchangeable fonts, matrix graphics, and parallel and composite video outputs. It can be addressed as 1k memory block.

Interactive Systems (Box 335, Jamison, PA 18929) is offering a pair of display units. The CDU-3216 (kit \$155, assembled \$189) is a 32-character-per-line, 16-line device with a 2-page capability; and the CDU-6416 (kit \$195, assembled \$220) is a 64-character-per-line, 16-line device with a 1-page capability. Both units have full cursor control and are contained on a single 9½" × 9¼" pc board and require a single +5-volt supply. Input data is 7-bit parallel and will load at an 80k-bit rate. The carriage return-line feed control characters are decoded and there are six spare codes that can be user defined.

From up Canada way, Matrox Electronic Systems (Box 56, Ahuntsic Stn., Montreal, Canada H3L 3N5; Tel: 514-481-6838) is now making available its MTX-1632SL (\$225), a RAM-like video display device that produces 32 characters per line on a 16-line format, and "looks" like a conventional 512×8-bit RAM. The 128-character set features a 7×9 matrix with upper and lower case. Since each character on screen corresponds to a memory location, the full power of the computer is available for data display manipulation. The device requires no external refresh and has a 550-nanosecond access time, TTL compatibility, character blinking, and uses a single +5-volt supply. A unique feature of this video system is that it accepts external H and V sync that allows the display to be locked to any external sync source for video tiling, and other uses. The system output is conventional video.

**Mass Storage.** Micro Designs Inc. (1175 Colusa Ave., Berkeley, CA 94707; Tel: 415-526-7794) has introduced a pair of new digital cassette mass storage systems with up to 1-megabyte(!) memory. Each of these systems features complete file management soft-

ware that allows the user to manipulate both symbolic and binary files with high-level commands. The Model 100 (\$550) uses a single cassette drive and stores ½-megabyte of data. The disc-like format allows access to any 128-byte record, the data transfer rate is 1000 bytes per second, and the tape can be searched at rates faster than 120"/second. The Model 200 (\$825), featuring dual transports, puts one-megabyte on line.

Both units come assembled and ready for installation in an Altair bus. To bring up the operating system, the user loads a cassette, and transfers control to a ROM on the interface board. All further operations are automatic. Status lights keep tabs on relevant tape conditions, and hardware error detection is provided as well.

**Z-80 Stuff.** Technical Design Labs, Inc. (Research Park, Bldg H, 1101 State Rd., Princeton, NJ 08540; Tel: 609-921-0321) announces a Z-80 CPU card (\$269) that is compatible with the Altair bus, and is designed to replace the current 8080 or 8080A CPU's. There are two on-board clocks—one crystal controlled and the other variable from dc to well beyond the limits of the Z-80. The use of the Z-80 dynamic refresh capability is made by bringing this signal out to the bus, making possible simple and inexpensive dynamic memory designs.

The pc boards are made from FR4 epoxy, with full solder mask and silk screen, all IC's are socketed, and each package contains full documentation including the Zilog Z80 manual, as well as the 1k Monitor and source code.

Also available from this same firm is their line of ZAPPLE software for the

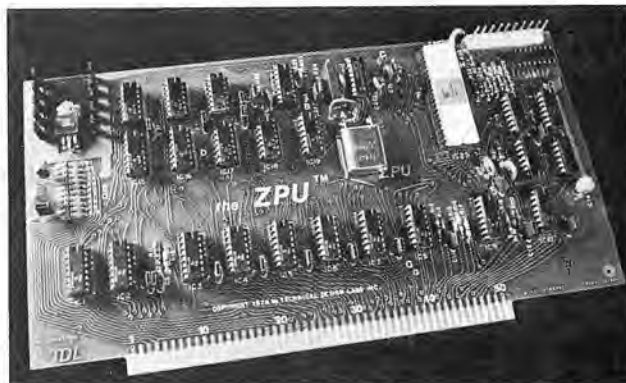


*Interactive Systems' CDU-3216 is one of two new display units.*

Z-80. Five software packages are currently available at \$150 each, with complete user's manuals. Monitor documentation includes the source code so that the hardware independence feature of Zapple software may be fully realized.

The Zapple Monitor occupies 2K of RAM and offers 27 instructions which includes full program debug capability, I/O handling, and modular organization to allow expansion with user-provided routines. The Zapple Text Editor occupies 3k of RAM and is both line and character oriented, which allows maximum user freedom in text manipulation as well as speed improvement over similar 8080 editors. The Zapple Re-locating Macro Assembler occupies 8k of RAM and features the ability to generate fully relocatable object code, allows infinite nesting of Macros, and many other features. A linking loader extension will soon be available. Zapple Basic occupies 8k of RAM and features all "normal" commands, including complete text editing facility, a List Variables statement that allows internal variables to be observed and/or modified during execution, a trace command that displays line numbers while they are being executed, and a renumber command to

*This ZPU card from Technical Design Labs, Inc., is compatible with the Altair bus.*



allow line number change according to any starting and interval parameters. Zapple Script is a word processor that occupies 3k of RAM or ROM and allows complete word processing capability including automatic paging, justification, concatenation, spacing, titling, and sub-titling, and other formatting functions.

**Some New Software.** Binary Systems Inc. (634 S. Central Expressway, Richardson, TX 75080; Tel: 214-231-1096) has introduced a new interpreter program for 8080 machines. Called BASIC ETC., the new interpreter was co-developed by John Arnold and Dick Whipple, authors of Tiny BASIC.

BASIC ETC. uses the lower 8K of memory plus at least 1K of RAM for scratchpad. Because this new language was designed for games and business applications, the less frequently used scientific functions of Dartmouth BASIC are not available. It does have full string capability (up to 255 characters per string), N-dimensional arrays, variable precision arithmetic, handles assembly language routines, direct memory and I/O addressing, 27 error codes, character and line erasure editing, permits sub-routine nesting, 31 commands and statements, 8 functions plus user defined functions, null control from 0 to 25 seconds, and formatted outputs.

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BASIC ETC is supplied on either KC audio tapes or paper tape for \$25, including a 32-page detailed users manual. The manual alone sells for \$6.

Tychon, Inc. (Box 242, Blacksburg, VA 24060; Tel: 703-951-9030) has developed some more interesting software for 8080-type machines. These include an Editor/Assembler tape (\$25, listing \$40), D-Bug tape (\$10, listing \$40), or a documentation package (\$5) which includes all the operating instructions for the editor, assembler, and D-Bug. These programs require 4k of RAM, and are available in 1702A or 2708 ROM. Each software package includes complete documentation on its use and information about changes for different I/O formats.

The Editor and Assembler are used to prepare programs from mnemonic and symbolic statements. The D-Bug package allows changes to be made in a program through a terminal or TTY. D-Bug also has single-step, breakpoint, paper tape read/punch routines, plus 13 useful subroutines.

If you do your own thing, Tychon also makes available its 8080 Octal Code Card (\$2.95) which is a slide-rule type of aid for programming and debugging 8080 software. It contains all the 8080 mnemonics and corresponding octal codes. All instructions are color-coded to indicate which flags are affected during execution. The card is 6.5 by 3 inches, and the rear side contains the ASCII code chart for all 128 characters, plus the 8080 status word and register pair codes.

Pro-Log Corp. (2411 Garden Rd, Monterey, CA 93940; Tel: 408-372-4593) is making available "The Design-

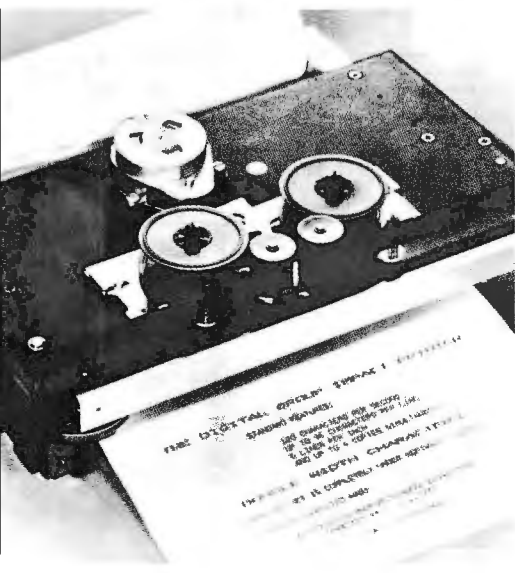
er's Guide to Programmed Logic—Featuring the 8080 Microprocessor" for \$7.50. This 148-page book covers the applications of programmed logic and features specific uses of 8080-type processors. It is profusely illustrated with drawings and tables, and contains numerous sample programs and experiments that demonstrate programming and program/hardware integration.

Intel Corp. (3065 Bowers Ave., Santa Clara, CA 95051) now has an expanded user's library named Insite™ (Intel Software Index and Technology Exchange). The library contains over 200 programs for 8080 and 8008 and over 100 programs for 4040 and 4004 systems. The new Program Library Manual contains all programs with listings up to three pages long. Programs longer than three pages are described in authors' abstracts. Update packages will be published every other month. Paper tapes containing source code for each program are available for a handling fee of \$15. As a bonus, new members receive five free source tapes of their own choice.

One-year membership is free to persons contributing acceptable programs, and the fee for others is \$100 annually. Members receive the program library manual and update packages during the term of their membership. Key among the new library programs are two BASIC compilers for the 8080A. One executes on a paper tape system, while the other requires a disc system. Both are available for a \$15 reproduction price.

If you are looking for a new source of computer hobbyist books, try the Computer Hobbyist Book Club (5405 B Southern Comfort Blvd., Tampa, FL 33614; Tel: 813-886-9890). They have a free flier upon request.

**Micro-Navigation.** A unique use for a microprocessor was brought to our attention recently. Developed by R.W. Burhans (161 Grosvenor St., Athens, OH 45701; Tel: 614-594-7184 or 614-593-8207) and called the Mini-L, the system was designed for experimental study of the Loran-C, 100-kHz navigation system. The circuit generates 10-microsecond interrupt requests that are locked to the extremely accurate Loran-C signals, making it easy for microprocessor users to devise their own time-measurement software. A 26-page experimenters' manual and two pc board (no components supplied) are included in the kit. A limited number of kits are available. Contact R.W. Burhans for further data. ◇



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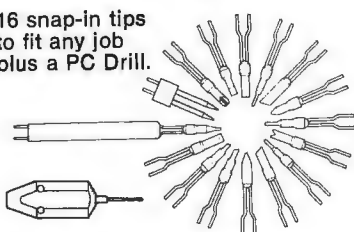
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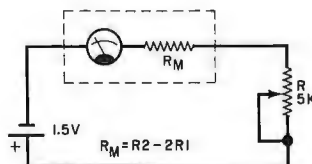
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## Tips & Techniques

### DETERMINING METER RESISTANCE

Most of us, at one time or another, have had to determine the internal resistance of a meter. This circuit shows one method of getting an accurate measurement. Resistor  $R_M$



represents the internal resistance (unknown), and  $R$  is a 5000-ohm potentiometer (almost any one will do). The 1.5-volt battery should be a fresh flashlight cell. After breadboarding the circuit, adjust  $R$  for full scale deflection of the meter. Then remove  $R$  and measure its resistance. Record the value as  $R1$ . Next, put  $R$  back in the circuit, but this time adjust it for one-half scale deflection. Then remove  $R$  and measure its resistance, and record it as  $R2$ . Finally use the equation  $R_M = R2 - 2R1$  to determine the unknown resistance.—*Ralph C. Born, Jr.*

### MULTI-TURN AIR-CORE COILS

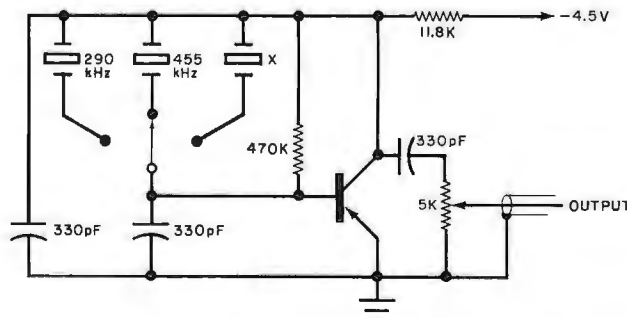
Specific values of inductance are often required by speaker crossover networks. The following formula gives the inductance of a closely wound, multi-layer, air-core coil with a rectangular winding cross-section. Accuracy is within 1 or 2%.

$$L = [(2m)^2 / (b + 1.5t + r)] F_1 F_2 \times 10^{-9} \text{ H}$$

where  $r$  is the mean radius of the inductor in

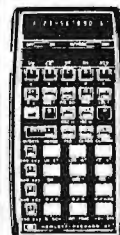
### TWO-WAY SECOND I-F SPOTTER

This circuit was built to check 2-way mobile radios having 290- or 455-kHz intermediate frequencies. Two crystals, one at 455 kHz and the other at 290 kHz, determine the frequency of oscillation. The switch is set to se-



lect the appropriate crystal. The output level of the oscillator is adjusted by the setting of the 5000-ohm potentiometer. The output level is sufficient for use in adjusting the rig's second i-f. A third crystal can be included for a marker or other fixed frequency output.—*Bob Goff*

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**Bogen** Model TR 54B and R 135BT pocket pagers. Need schematic and service manual. Michael Sarembski, 53 Rutledge Rd., Scarsdale, NY 10583.

**Superior Instrument** Model TV-60 VOM. Hallicrafters Model S-107 shortwave receiver. Need operators manuals and schematics. Mike Kocak, 2369 Maryland Ave., #2, Cincinnati, OH 45204.

**Akai** Model M-7 stereo tape recorder. Service and operating manuals needed. M. J. Olah, 1100 Merriman Rd., Akron, OH 44303.

**Wedgefield** Model CS-506 cassette recorder. Schematic needed. H. M. Smith, 9852 Dandelion Ave., Fountain Valley, CA 92708.

**Milovac** Model TR-525 AM radio. Need schematic for antenna and RF stage. Norman R. Damborg, 221 So. 184 St., Seattle, WA 98148.

**Stewart Warner** Model R 181-A. Schematic and alignment instructions needed. Gary Bodnar, 36 Wildwood Ave., East Lansdowne, PA 19050.

**International Crystal** Model MO11 mobile transceiver. Schematic and/or service manual. William E. Olson, Box 245, Cedar Hill, MO 63016.

**Frigistor**, 32 couple module. Need source of. R. Kelsey, P. O. Box 12, Pinconning, MI 48650.

**Dayton Fan and Motor Co.** Model 5046 5-tube radio. Schematic needed. Cedric Walker, 520 Green St., Durham, NC 27701.

**Marcony** Model 89 battery operated radio. Schematic needed. Mr. Alain Coulombe, Box 852, Grand Centre, Alberta Canada TOA 1T0.

**Clegg** Model 66 6-meter transceiver. Manual and schematic. Daniel Bodnarchuk, 138 W. Union Ave., B. Brook, NJ 08805.

**RCA** Model BC-342-D U.S. Army receiver. Schematic and service manual. Edward F. Maher, 489 Grand Blvd., Brentwood, NY 11717.

**Hallicrafters** Model SX42. Need source of tuning gear train, tuning knobs, shafts and main escutcheon. J. McClelland, 7110 Vernon, St. Louis, MO 63130.

**Circosonic** Model PG-8 ultrasonic cleaner. Need schematic or service manual. Bob Mooney, 72300 Varner Rd., 1000 Palms, CA 92276.

**Ampro** Model 758 open-reel tape deck. Toyo Model CHR-655 remote control unit. Need operation manuals or any available information. C. Leigh, Sprinkle Rd., #2, Box 25, Jackson, NJ 08627.

**Hallicrafters** Model R-649/UR Coast Guard radio receiver. Schematic and/or instruction manual. S. G. Blair, 1201 Palekaiko St., Pearl City, HI 96782.

**Sylvania** Model 145 audio oscillator. Schematic and service information needed. Brian R. Oppegaard, 127 Orchard Trace #8, Charlotte, NC 28213.

**Magnatone** Model 30 B music amplifier. Schematic needed. Charles E. Hopper, 9002 E. 68th St., Raytown, MO 64133.

**Knight** Model 83Y809-601014 604 Safari-1 CB transceiver. Schematic or service manual needed. Robert P. Hanes, 848 Mitchell St., Erie, PA 16509.

**RCA** Type 69-C MI-7512 distortion and noise meter. Operations manual needed. Danny Biando, P. O. Box 8653, San Jose, CA 95155.

**Supreme Instruments** Model 565 VTVM. Schematic, parts list and/or service manual needed. Daniel R. Lee, Rt. 1, Box 145A, Subiaco, AR 72865.

**U.S. Navy** Model PP-374/VRC-56 power supply. Need any available information. Mr. David O. Hansen, Broadmoor Park #B-38, 55 West Washington Ave., Yakima, WA 98908.

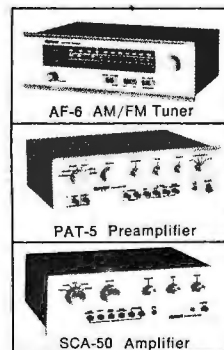
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**Western Electric** Model BC-453-B U.S. Army radio receiver. Need schematic and manual. Paul White, 1225 N. Hollywood Dr., Fullerton, CA 92631.

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**Symphonic** Model TPS-30 mini TV. Need source of 3-inch picture tube. Richard Grepke, RR#5, Ft. Wayne, IN 46818.

**Lear** Model LR-6A VHF receiver and Model RT-10E VHF transmitter. Service information needed. Kenneth R. Duncan, 930 Merrill Ave. S.W., Grand Rapids, MI 49503.

**Hammarlund** Model SP-600 receiver. Need schematic, service manual, alignment instruction and parts list. Jun Villanueva, 1332 26th Ave., San Francisco, CA 94122.

**Stromberg-Carlson** Type CCT-45106 radio receiver. Need tuning knob, schematic, dynamotor and service manual. Steve Swift, 7807-218 S.W., Apt. #54, Edmonds, WA 98020.

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**Raytheon** Type CK 5676 tube. Need source of supply. G. Wintress, P. O. Box 373, Mt. Freedom, NJ 07970.

**Lafayette** 99C9037 amplifier module, 99C6034 transformer. Source or equivalent with diagrams. Gene Wong, 6103 Beatrice St., Vancouver, B.C., Canada V5P 3R3.

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**Supreme Instruments** 546 oscilloscope, serial number 2497. Company address or source of parts. Jack Martin, 576 Greenbriar, Fairfield, TX 75604.

**Lafayette** PB-50 low-band vhf tuneable public service monitor. Schematic or owner's manual. Fred F. Helmstetter, Omicron Radio Repair, 14 Lincoln Ave., Chatham, NJ 07928.

**Beckman** 727OR time-interval meter. Schematic. S. Goldhar, 1014 B. St., Hayward, Calif. 94541.

**AC Cossor** 1049 MK2 scope. **AC Cossor** 1434 preamplifier. **Seris** 22A signal generator. **Aico** 625 tube tester. Service manual, operating manual, schematic. Claude Houde, 7427 Boyer St., Montreal, P.Q., Canada H2R 2R9.

**WRL Electronics** Globe Chief 90-A. Schematic, owner's manual, service info. R. Begnoche, 11175 Roberts, Stockbridge, MI 49285.

**Wells-Gardner** RBL-3 low-frequency Navy receiver. Complete technical manual with schematics. Ron Hammock, 966 - 21st Ave., Seattle, WA 98122.

**McMurdo Silver** Vmax 900 VTVM. Service manual. Robert C. Pease, 340 4th Ave., Stanley, WI 54768.

**Heathkit** AR-3 shortwave receiver. Schematics and any other info. Stan Moore, Jr., Box 26, Thermopolis, WY 82443.

**Wanlass** Model MP power supply. Schematic, service info. Paul Barker, 4422A Myrtlewood Dr., Huntsville, AL 35805.

**Akai** VC-150 color camera, VT-150 color recorder, VTS-150 recording system. Complete info. K. Samad, Box 50072, Washington, DC 20004.

**Dumont** 324 scope. Manual, schematic. Deryl B. Shields, 16533 - 37th N.E., Seattle, WA 98155.

**Superior Instruments** TV-50 genometer, 6704 VOM. Manuals and schematics. Charles T. Allen, 6746 Parkinson Dr., Miami Lakes, FL 33014.

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**Motorola** 14P4-1. Schematic, parts list. Dean E. Cesa, 3924 Radcliffe Dr., Northbrook, IL 60062.

**Heathkit** AJ-30 tuner. FM multiplex adapter. Jerry W. Bolin, 16576 Sarah St., Mojave, CA 93501.

**Clevite** TO-01A transfilter. Source. David A. Darling, Stadium Dr. Tr. Ct. #8A, Moscow, ID 83843.

**Dyna Quik** 675 mutual transconductance tester. Need card 41, or copy of numbers punched out on card 41. Anton S. Melka, RFD Rt. 1, Box 55, Butte, MT 59701.

**Sonora** Model C radio. Info and schematics. A.C. Crimmel, 11210 Rannoch La., Louisville, KY 40243.

**Fisher Research** Skipper marine-band transceiver. Schematic and any other info. Paul Prescott, Allen Rd., Brookfield, CT 06804.

**Tele-Instrument** 2113 TV signal generator. Schematic, manual, any info. Charles King, 6 Willow Ct., Cromwell, CT 06416.

**General Electric** 250 portable radio, uses 2-V plug-in wet storage battery. Source for battery, schematic, plastic dial, service manual, or set to cannibalize. Ole G. Morby, 15 Sturges Commons, Westport, CT 06880.

**Aiwa** TP-728 cassette recorder. Schematic. Paul Montor, 1040 N. Martin Rd., Janesville, WI 53545.

**Links** 1905-2G vhf transceiver. Schematic. Clinton E. Hartsfield, R.B. Electronics, 3009 Alta Mira Dr., Richmond, CA 94806.

**Johnson** Viking 6NZ converter. Instruction manual, schematic. Arthur Gillman, 14 Pine St., Princeton, NJ 08540.

**Longines Symphonette** AM/FM/cassette recorder. Instruction manual, schematic. Roy O. Kroeger, 104 N. Michigan, Roswell, NM 88201.

**Autovox** OC-401 shortwave mobile converter. Source. G.E. Ferguson, 3905 Clayton Rd., Apt. 14, Concord, CA 94521.

**Rondine** B-12H turntable. Schematic and any other info. Anthony A. Gihrdanella, Box 31, Star Rte., Chatham, NY 12037.

**DeVry** IC/QEB-10 sound movie projector. IC/QPB-ID manual and parts. Fabian Bourge, Box 626, Vinton, LA 70668.

**Philco** 41-245 receiver. Schematic, source of XXL tubes, info on last date of manufacture. R. Culbertson, 601 Cornplanter Ave., Oil City, PA 96301.

**Kent** 6620 musical-instrument amplifier. Schematic and any other info. David Baughman, 155 East Main St., Newark, OH 43053.

**Elmac** Trans-Citer AF-67 amateur transmitter. Harvey Wells Bandmaster R9-A receiver. Schematics, manuals. Paul Prescott, Allen Rd., Brookfield, CT 06804.

**Beckman** 797 decimal counting unit for Beckman 8379AR frequency counter and timer. Source. Danny Baidno, Box 8653, San Jose, CA 95155.

**ICS** meter, kit TK28653MS. Assembly manual. A.D. Lane, Box 1203, Framingham, MA 01701.

**Advent** 300 receiver. Schematic. R.K. Brush, 1965 E. 3375 South, Salt Lake City, UT 84106.

**Knight-Kit** KG-389 fuzz box. Schematic, parts list, layout. Joseph Viau, 84 Friendly Rd., Cranston, RI 02910.

**General Electric** 260 radio. Schematic, source of 1LC6, 1LN5, 1LN4, 3Q5(GT/G) tubes. Roberto Leal, Kelley's Tr. Ct. #5 Lot 8, Alexandria, VA 71301.

**Globe** 65-220 Globemaster CB radio. Power transformer. **Motorola** FM TRU-5V taxi radio. Components Q-8528, PA 8548; schematics, source, plugs, etc. Tom Ash, Route 7, Box 105, Mortantown, OH 26505.

**Waterman** S-14-B Pocketscope. Schematic, manual. George Kabroth, 218 N. Arch St., Mechanicsburg, PA 17055.

**Hammarlund** HQ-129-X shortwave receiver. Hookup diagrams for antenna and any other info. Paul Ziemba, 3616 Greenbriar, Midland, MI 48640.

**Paco** V-70. Schematic, calibration instructions (with layout of adjustment controls.) Will buy or copy. Howard Adams, 209 W. Shadywood Dr., Midwest City, OK 73110.

**Loewe** Oplacord 403 tape recorder, serial number 09014.

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Operation manual and/or schematic, parts list. Stefan Pawlikowski, Apt. 8, 2 Grace St., Wawa, Ontario, Canada POS 1K0.

**Hickok** 18 signal generator. Schematic, service and operation manuals, and any other info. D. Engen, 2804 Spencer-ville Rd., Burtonsville, MD 20730.

**Hallicrafter** SRO receiver. Calibrated dial scale (083-000982), trim plate panel (007-000793). John Allanson, 515 Pleasant St., New Glasgow, Nova Scotia, Canada B2H 3A1.

**Concord** 994 tape recorder. Schematic. Marion B. Harrelson, 6400 Liberty Rd., Baltimore, MD 21207.

**Hallicrafter** SX-43 receiver. Wiring diagram. Speaker impedance info. Kenneth A. Sheets, 38 Mayfield Hts., Beaver Falls, PA 15010.

**Dumont** 304A scope. Operating and maintenance manuals. Edward Medovich, 14B Old Hickory Dr., Apt 2A, Albany NY 12204.

**Superior** 77 VTVM. Source of 9006 tubes, or substitute. George Snell, Lakeside Rd., Waterport, NY 14571.

**Eldico** SSB-100MIL (MARS) exciter/transmitter. Instruction manual and/or schematics. Harold Screven, 90 Jamie St., Islip Terr., NY 11752.

**Jackson** TVG-2 TV signal generator, serial 4158. Operation manual, schematic. J.D. Nasmith, 311 Bunting Rd., Unit #9, St. Catharines, Ontario, Canada L2M 3Y4.

**Hallicrafter** SX-28 Super Skyriider receiver. Need wire-wound, metal-cased resistor for voltage divider. Fred Berrier, 1126 Phillips Ave., Knoxville, TN 37920.

**U.S. Govt.** R-392/URR receiver, 500 kHz to 32 MHz. Voltage requirements, operator manual, source of power supply and speakers. Cande Palermo, 83 William St., Yonkers, NY 10701.

**Columbian** Aqua-Probe CB303 depth finder. Schematic, parts list. Buy or pay for copy. Kermit D. Lloid, Rte. 1, Box 1360 Natchitoches, LA 71457.

**Heathkit** GW-10 CB transceiver, circa 1961. Tube-location

diagram. John D. Harmon, 22107 Blackburn, St. Clair Shores, MI 48080.

**Beckman** 727OR interval counter. Schematic. S. Goldhor, 1014 B. St., Hayward, CA 94541.

**Unisonic** 817L desk calculator. Schematic, parts list. Joseph F. Schussler, 20 Dorett Dr., Wappingers Falls, NY 12590.

**Motorola** CP-30FN tape recorder. Schematic. Michael Persic, 18021 Karen Dr., Encino, CA 91316.

**American Concertone** 505 reel-to-reel tape recorder. Schematic, parts list, or any info. Duncan Crawford, 160 E. Holmes Hall, E. Lansing, MI 48824.

**Grundig-Majestic** 7000, circa 1957. Schematic. A. Chandler, 2707 38th St. W., Bradenton, FL 33505.

**Sears** 570 AM/FM-stereo receiver. Schematic, operating manual., Ned Black, RFD #1, S. Windham, ME 04082.

**HFE** T4214A oscillograph, made in England. Schematics, any other info. Barry Fuerst, 218 Flourmoy St., Oak Park, IL 60304.

**Eico** 753 transceiver. Schematic, operation and assembly manual, parts list. Leland D. Walton, 1189 El Sendero, Salt Lake City, UT 84117.

**Hammarlund** SP600/X21, serial 20414. Schematic and/or service manual. Pollak Gabriel, POB 9029, Beer-Sheva, Israel.

**Philco** 37-630 AM/SW receiver, cabinet code 122-type T, circa 1936-37. Need glass dial-cover and ring. Also need Philco High Efficiency Aerial supplied with receiver. F. Keith Hayward, Box 537, Angier, NC 27501.

**Stromberg-Carlson** 863 receiver. Schematic and any other info. Randy Baker, 2 Beckfoot Dr., Dartmouth, Nova Scotia, Canada B2Y 4C8.

**Majestic** 62A table radio. **General Electric** GE-93 radio. Schematics. R. Smith, 3188 Rumsey, Ann Arbor, MI 48105.

**Stephens** Tru-Sonic multi-cellular midrange horn speaker

system. Replacement P-M driver needed. Frank J. Burris, 35640 Ave. F, Ycaipa, CA 92399.

**Viking** 85 tape deck. Operating and service manuals. William Lee, 4 Mallard Dr., Center Moriches, NY 11934.

**Milovac** CT711 TV, serial F00318. Need service info. Clinton Chamberlin, 10 Old North Rd., Walden Park, Mountaintop, PA 18707.

**U.S. Govt.** APX-6/RT-279 transponder. Schematic, service and operating manuals, also data on conversion to 1215 MHz needed. Nick Raeside, Wildwood Cres., RR #3, B.C., Canada V0S 1E0.

**Hammarlund** HQ-170A amateur receiver. Any and all information, also antenna coils for any band. Will buy HQ-170A for cannibalization. Wayne Stratton, 11426 Stewart Lane, Silver Spring, MD 20904.

**Leitch** 21-56 Meter-Matic VTVM. Schematic or tube layout needed. Noor S. Khalsa, 242 Oxford St., Hartford, CT 06105.

**U.S. Govt./Landers, Fray & Clark** AN/URM-105 multimeter; S/N 2749; Order No. 4930-PP-61. Schematic, operations manual. Ray Miller, Box 181, Antioch, CA 94509.

**General Electric** A-87 radio. Schematics and/or service manuals. Mel Peterson, 778 Richland Rd., Yuba City, CA 95991.

**Wire recorder**, wanted to borrow or rent for transcribing old recordings. C.R. Opela, 203 Asbury, Evanston, IL 60202.

**Jackson** TVG-2 signal generator. Schematic and calibration data. **B&K** 500 tube tester. Most recent charts, calibration data, schematic. Mike Miller, 20 Hemlock Ave., Sonoma, CA 95476.

**Hammarlund** HQ-170 receiver. Schematic, service and operation manuals. Douglas Coverdale, RR #3, Box 77A, Nobbsville, IN 46060.

**U.S. Army Signal Corps** TS175C/U frequency meter. Need operating manual. J. Allen Call, 1876 E. 2990 S., Salt Lake City, UT 84106.

**Premier** reverb. Schematic, tube types. Steve Andrusyshyn, RD #3, Diemer's Hill, Pottsville, PA 17901.

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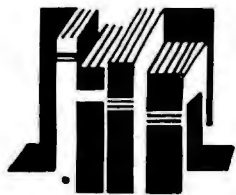
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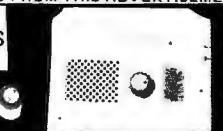
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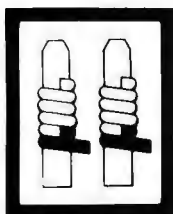


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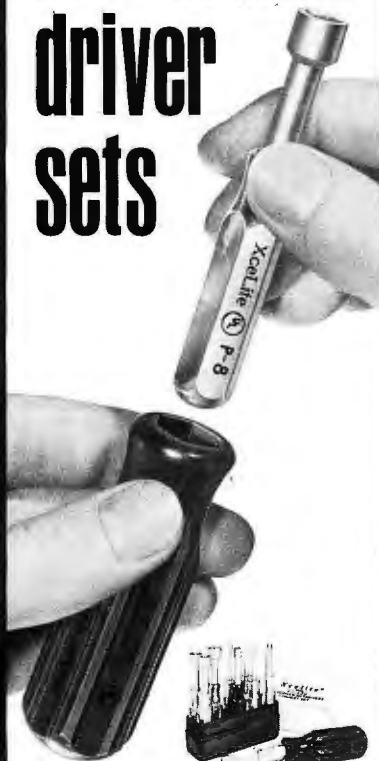


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1 Meg. \$7.5 each	\$32.00
MULTI-TURN TRIM POTS Similar to Bourns	
3010 style 3/16"x5/8"x1 1/4": 50, 100,	
1K, 10K, 50K ohms	\$1.50 ea.
1K, 10K, 50K ohms	\$3.50 ea.
LIGHT ACTIVATED SCR's	
TO-18, 200V 1A.	\$ 1.75
<b>TRANSISTOR SPECIALS</b>	
2N3585 NPN Si TO-66	\$ .95
2N3772 NPN Si TO-3	\$ 1.60
2N4564 PNP GE	\$ .75
2N4908 PNP Si TO-3	\$ 1.00
2N6056 NPN Si TO-3 Darlington	\$ 1.70
2N5086 PNP Si TO-92	4/\$ 1.00
2N4898 PNP TO-66	\$ .60
2N4044 PNP GE TO-5	5/\$ 1.00
2N3919 NPN Si TO-3 RF	\$ 1.50
1NPSA 13 NPN Si TO-92	3/\$ 1.00
2N3767 NPN Si TO-66	\$ .70
2N2222 NPN Si TO-18	5/\$ 1.00
2N3055 NPN Si TO-3	\$ .80
2N3904 NPN Si TO-92	5/\$ 1.00
2N3906 PNP Si TO-92	5/\$ 1.00
2N5296 NPN Si TO-220	\$ .50
2N6109 PNP Si TO-220	\$ .55
2N3638 PNP Si TO-5	5/\$ 1.00
2N6517 NPN TO-92 Si	3/\$ 1.00
<b>CMOS (DIODE CLAMPED)</b>	
74C02 - 22 4015 - 95 4029 - 110	
74C10 - 22 4016 - 40 4030 - 22	
74C193 - 150 4017 - 1.05 4033 - 150	
4001 - 22 4018 - 1.00 4035 - 110	
4002 - 22 4019 - 25 4042 - 78	
4006 - 1.70 4020 - 1.05 4046 - 2.25	
4007 - 22 4022 - 95 4047 - 2.00	
4009 - 42 4023 - 22 4049 - 40	
4010 - 42 4024 - 75 4050 - 40	
4011 - 22 4025 - 22 4055 - 150	
4012 - 22 4026 - 1.25 4066 - 80	
4013 - 40 4027 - 40 4071 - 22	
4014 - 22 4028 - 86 4076 - 1.05	
IN 4148 (IND14)	15/\$1.00
MCA 81 OPTICAL LIMIT SWITCH	\$1.50
<b>LED READOUTS</b>	
FND 359 C.C.	\$ .55 MAN-7-3" C.A.
FND 503 C.C.	\$1.05 NS 33-3 digit array
FND 510 C.A.	\$1.05 DLT 747 C.A.
HP 7740-3 C.C.	\$1.25

<b>PRINTED CIRCUIT BOARD</b>	
4-1/2" x 6-1/2" SINGLE SIDED EPOXY BOARD 1/16" thick, unetched	5/\$2.60
<b>7 WATT LD-65 LASER DIODE IR \$8.95</b>	
2N 3820 P FET	\$ .45
2N 5457 N FET	\$ .45
2N2646	\$ .45
ER 900 TRIGGER DIODES	4/\$1.00
2N 6028 PROG UJT	\$ .65
8 PIN DIP SOCKETS	\$ .24
14 PIN DIP SOCKETS	\$ .25
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18 PIN DIP SOCKETS	\$ .30
24 PIN DIP SOCKETS	\$ .30
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<b>VERIPAK PC BOARD</b>	
This board is a 1/16" single sided paper epoxy board, 4 1/2" x 6 1/2" DRILLED and ETCHED which will hold up to 21 single 14 pin IC's or 8, 16, or LSI DIP IC's with busses for power supply connector.	
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MV 5691 YELLOW-GREEN	
BIPOAR LED	\$1.25
FP 100 PHOTO TRANS	\$ .50
RED, YELLOW OR GREEN	
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MC6860 MODEM CHIP	\$9.95
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LM 376	\$ .60 340T-5, 6, 8, 12
320K-5 or 15V \$1.40	15, 18 or 24V \$1.10
320T-5, 12, 15	78 MGS \$1.35
or 24V \$1.25	78 MGS \$1.35
<b>RS232</b>	
male	\$3.25
female	\$3.95
<b>CONNECTORS</b>	

<b>TANTALUM CAPACITORS</b>	
22UF 35V 5 \$1.00	6.8UF 35V 3 \$1.00
47UF 35V 5 \$1.00	22UF 35V \$ .40
82UF 35V 5 \$1.00	30UF 6V \$ .40
1UF 35V 5 \$1.00	33UF 35V \$ .40
2.20UF 20V 5 \$1.00	47UF 20V \$ .35
3.3UF 35V 4 \$1.00	100UF 35V \$ .35
4.7UF 10V 5 \$1.00	100UF 15V \$ .50
<b>M7001 ALARM CLOCK CHIP</b>	
	\$5.75
<b>NATIONAL MOS DEVICES</b>	
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MM5013 - 2.50	MM5061 - 2.50
MM5016 - 2.50	MM5555 - 4.75
MM5017 - 2.70	MM5556 - 4.75
MM5055 - 2.25	MM5210 - 1.95
MM5056 - 2.25	MM5260 - 1.75
<b>TTL IC SERIES</b>	
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7402 - .15	7447 - .70
7403 - .15	7448 - .70
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7430 - .20	7496 - .70
7432 - .25	74107 32
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7442 - .52	74132 82
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7408	276-1822	\$ .49	29c
7410	276-1807	\$ .49	29c
7413	276-1815	\$ .19	69c
7420	276-1809	\$ .49	29c
7427	276-1823	\$ .69	39c
7432	276-1824	\$ .69	39c
7441	276-1804	\$ .59	89c
7447	276-1805	\$ .99	89c
7448	276-1816	\$ .99	89c
7451	276-1825	\$ .49	29c
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7474	276-1818	\$ .79	39c
7475	276-1806	\$ .19	69c
7476	276-1813	\$ .79	49c
7485	276-1826	\$ .59	99c
7486	276-1827	\$ .69	49c
7490	276-1808	\$ .19	69c
7492	276-1819	\$ .19	69c
74123	276-1817	\$ .69	89c
74145	276-1828	\$ .19	1.19
74150	276-1829	\$ .79	1.39
74154	276-1834	\$ .79	1.19
74192	276-1831	\$ .69	99c
74193	276-1820	\$ .69	99c
74194	276-1832	\$ .69	1.19
74196	276-1833	\$ .69	1.19

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Type	Cat. No.	Reg.	SALE
74C00	276-2301	\$ .69	39c
74C02	276-2302	\$ .69	39c
74C04	276-2303	\$ .69	39c
74C08	276-2305	\$ .69	39c
74C74	276-2310	\$ .29	59c
74C76	276-2312	\$ .59	69c
74C90	276-2315	\$2.29	99c
74C192	276-2321	\$2.49	1.29
74C193	276-2322	\$2.49	1.29
4001	276-2401	\$ .69	39c
4011	276-2411	\$ .69	39c
4013	276-2413	\$ .29	89c
4017	276-2417	\$2.49	1.49
4020	276-2420	\$2.49	1.49
4027	276-2427	\$1.29	89c
4049	276-2449	\$ .99	69c
4050	276-2450	\$ .99	69c
4511	276-2447	\$2.69	1.69
4518	276-2490	\$2.49	1.49

## Linear ICs

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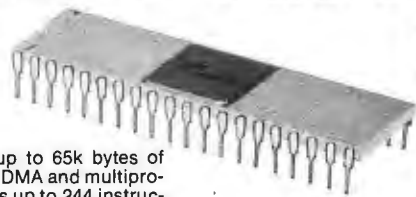
Type	Cat. No.	Reg.	SALE
301AH	276-017	\$ .69	29c
324N	276-1711	\$ .99	1.49
339N	276-1712	\$ .99	1.49
386CN	276-1731	\$ .99	99c
555CN	276-1723	\$ .49	89c
556CN	276-1728	\$2.99	1.29
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723CN	276-1740	\$ .99	59c
723H	276-009	\$ .99	59c
741CN	276-007	\$ .69	35c
741H	276-010	\$ .69	35c
3900N	276-1713	\$ .99	59c
3909N	276-1705	\$1.29	99c
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## 8080A Microcomputer Chip

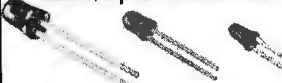
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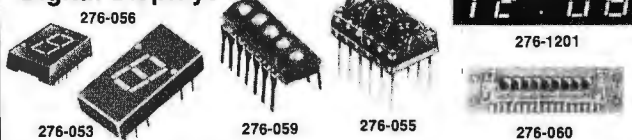


## LEDs/Optoelectronics



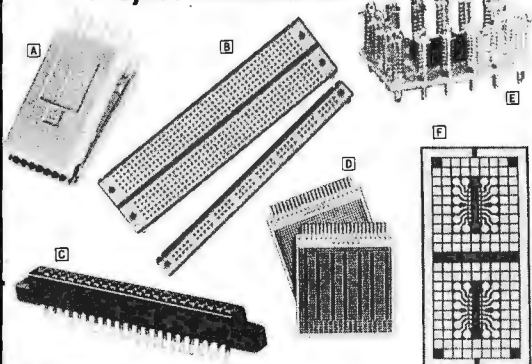
Item	Cat. No.	Reg.	SALE
L Red LED	276-041	2/99c	2/69c
L Ctr LED	276-047	2/99c	2/69c
M Red LED	276-026	2/99c	2/69c
M Ctr LED	276-040	2/99c	2/69c
S Red LED	276-042	2/99c	2/69c
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Infrared Em.	276-141	\$1.19	
Solar Cell	276-115	\$1.49	
Photocell	276-116	\$ .99	
FPT 100	276-130	\$ .79	

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Digits	Size	Drive	Cat. No.	Reg.	SALE
1	0.3"	Anod.	276-053	\$2.99	1.99
1	0.3"	Cath.	276-062	\$2.99	1.99
1	0.3"	Anod.	276-1210	4/\$8.97	4/6.95
1	0.3"	Cath.	276-1211	4/\$8.97	4/6.95
1	0.5"	Anod.	276-056	\$3.99	2.99
1	0.5"	Cath.	276-066	\$3.99	2.99
3	0.120"	Cath.	276-055	\$1.49	99c
5	0.110"	Cath.	276-059	\$1.99	1.49
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4	0.5"	Cath.	276-1202	\$9.95	7.95

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- (B) Experimenter Socket. 2x47 rows of 5 connected tie points. 276-172 ..... 9.95
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- (D) 22-Pin Edge-Card Board Connector. 44-terminals. 276-1551 ..... 2.99
- (E) Standard Edge-Card Board. 22-pin. 1295 mounting holes. 276-152 ..... 2.99
- (F) 2-Voltage Source Edge-Card Board. 1368 mounting holes. 276-154 ..... 2.99
- (G) 3-Voltage Source Edge-Card Board. 1368 mounting holes. 276-153 ..... 2.99
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- (I) Experimenter's PC Board. Mount 2 IC's, 8, 14 or 16-pin. 276-151 ..... 2.49
- (J) Plastic Face Plates. 2x8x1/2". ..... 99c
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- Red Tint. 270-299 ..... 99c
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1N4001	276-1101	2/\$.39	2/29c
1N4003	276-1102	2/\$.59	2/39c
1N4004	276-1103	2/\$.69	2/49c
1N4005	276-1104	2/\$.79	2/59c
1N4735	276-561	2/\$.89	2/69c
1N4739	276-562	2/\$.89	2/69c
1N4742	276-563	2/\$.89	2/69c
1N4744	276-564	2/\$.89	2/69c
1N5401	276-1141	2/\$.69	2/59c
1N5402	276-1142	2/\$.89	2/69c
1N5403	276-1143	2/\$.99	2/79c
1N5404	276-1144	2/\$1.19	2/89c
1N914/4148	276-1122	10/99c	

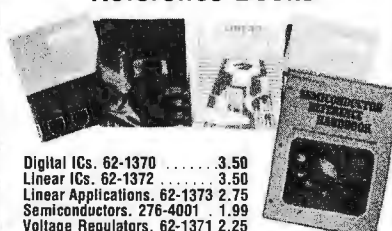


## SCRs and Triacs

Device	Rating	Cat. No.	Reg.	SALE
SCR	50V, 6A	276-1089	\$ .99	69c
SCR	100V, 6A	276-1090	\$1.29	79c
SCR	200V, 6A	276-1067	\$1.39	89c
SCR	400V, 6A	276-1020	\$1.49	99c
Triac	50V, 6A	276-1003	\$ .99	69c
Triac	100V, 6A	276-1002	\$1.29	79c
Triac	200V, 6A	276-1001	\$1.39	89c
Triac	400V, 6A	276-1000	\$1.49	99c



## Reference Books



- Digital ICs. 62-1370 ..... 3.50
- Linear ICs. 62-1372 ..... 3.50
- Linear Applications. 62-1373 2.75
- Semiconductors. 276-4001 ..... Sale 99c
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46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
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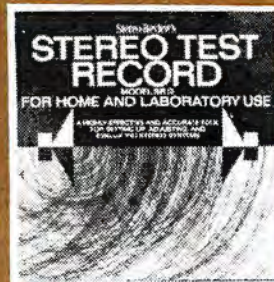
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Cat.No. 6E2597 100% good	<b>BARREL KIT #59</b> ROOMS-REGISTERS 75 for \$1.98 Unmarked 2K to 40 pin devices, marked internal factory numbers, to Cat.No. 6E2424	<b>BARREL KIT #58</b> SWITCHING DIODES 100 for \$1.98 Imagine famous switching diodes at these prices! Cat.No. 6E2418 Untested.	<b>BARREL KIT #57</b> RECTIFIERS 100 for \$1.98 1N1000 series. May include 25, 50, 100, 200, 400, 600, 800 and 1000 voltages. Cat.No. 6E2417	<b>BARREL KIT #56</b> SCRS, TRIACS, QUADRACS 40 for \$1.98 Raw factory stock. All the 10 amp types. Cat.No. 6E2419 Untested.	<b>BARREL KIT #55</b> DIODES 100 for \$1.98 Singles, duals, variety of values, styles, big ones & small ones. Cat.No. 6E2421	<b>BARREL KIT #54</b> VOLUME CONTROL 30 for \$1.98 Singles, duals, variety of values, styles, big ones & small ones. Cat.No. 6E2421	<b>BARREL KIT #53</b> TRANSISTORS 60 for \$1.98 All 4 leaders TO-18 case, includes UHF transistors too! Cat.No. 6E2429	<b>BARREL KIT #52</b> PRECISION RESISTORS 200 for \$1.98 Marked and unmarked 1/4, 1/2, 2 watt, No. 6E2428	<b>BARREL KIT #51</b> NPN HIGH-POWER TRANSISTORS 20 for \$1.98 Popular germanium TO-3 case. 6E2614 100% good	<b>BARREL KIT #50</b> POWER! POWER! 100 for \$1.98 Bargain of a lifetime! All we got was 1 barrel—the "blister digit" types. Multi-plexed. Cat.No. 6E2722	<b>BARREL KIT #49</b> A DIGIT READOUTS 10 for \$1.98 Bargain of a lifetime! All we got was 1 barrel—the "blister digit" types. Multi-plexed. Cat.No. 6E2722	<b>BARREL KIT #48</b> NATIONAL IC BONANZA HOBBY LENS 100 for \$1.98 Types 4000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linear, etc. All marked. Cat.No. 6E2860	<b>BARREL KIT #47</b> LITRONICS LED READOUTS 10 for \$1.98 717's, 727's, singles, tri-plex, etc. 33 to 0.6. But from factory, lot mixed, have fun! No. 6E2861	<b>BARREL KIT #46</b> NATIONAL IC BONANZA HOBBY LENS 100 for \$1.98 Types 4000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linear, etc. All marked. Cat.No. 6E2860	<b>BARREL KIT #45</b> 2 WATERS 100 for \$1.98 Suppliers throw 'em in the barrel. It's a 1/4 good mine. All marked. Cat.No. 6E2735	<b>BARREL KIT #44</b> MIXED READOUTS 10 for \$1.98 Factory returns—such numbers as MAN-4's, MAN-7's, MAN-3's, 11 barrels & no time to separate. Cat.No. 6E2733 Untested.	<b>BARREL KIT #43</b> PNP HIGH-POWER TRANSISTORS 20 for \$1.98 Popular germanium TO-3 case. 6E2614 100% good	<b>BARREL KIT #42</b> METALLIC RESISTORS 100 for \$1.98 Made mostly by Corning, the finest resistor made. Mostly 1/2 watters. 1% to 5% tol. & a barrel of values. Cat.No. 6E2609	<b>BARREL KIT #41</b> LONG LEAD DISCS 100 for \$1.98 "Auction sale!" Prime, marked only. Long leads. Cat.No. 6E2598 100% good	<b>BARREL KIT #40</b> POLYSTYRENE CAPS 100 for \$1.98 Finest caps made. As a gamble we bought 10 barrels from factory, mixed values. All good. Cat.No. 6E2729	<b>BARREL KIT #39</b> DIPPED MYLARS 60 for \$1.98 Finest capacitors made, shiny finish. Imagine factory dumping 'em in barrels. Cat.No. 6E2597 100% good	<b>BARREL KIT #38</b> ROOMS-REGISTERS 75 for \$1.98 Unmarked 2K to 40 pin devices, marked internal factory numbers, to Cat.No. 6E2424	<b>BARREL KIT #37</b> SWITCHING DIODES 100 for \$1.98 Imagine famous switching diodes at these prices! Cat.No. 6E2418 Untested.	<b>BARREL KIT #36</b> RECTIFIERS 100 for \$1.98 1N1000 series. May include 25, 50, 100, 200, 400, 600, 800 and 1000 voltages. Cat.No. 6E2417	<b>BARREL KIT #35</b> SCRS, TRIACS, QUADRACS 40 for \$1.98 Raw factory stock. All the 10 amp types. Cat.No. 6E2419 Untested.	<b>BARREL KIT #34</b> DIODES 100 for \$1.98 Singles, duals, variety of values, styles, big ones & small ones. Cat.No. 6E2421	<b>BARREL KIT #33</b> VOLUME CONTROL 30 for \$1.98 Singles, duals, variety of values, styles, big ones & small ones. Cat.No. 6E2421	<b>BARREL KIT #32</b> TRANSISTORS 60 for \$1.98 All 4 leaders TO-18 case, includes UHF transistors too! Cat.No. 6E2429	<b>BARREL KIT #31</b> PRECISION RESISTORS 200 for \$1.98 Marked and unmarked 1/4, 1/2, 2 watt, No. 6E2428	<b>BARREL KIT #30</b> NPN HIGH-POWER TRANSISTORS 20 for \$1.98 Popular germanium TO-3 case. 6E2614 100% good	<b>BARREL KIT #29</b> POWER! POWER! 100 for \$1.98 Bargain of a lifetime! All we got was 1 barrel—the "blister digit" types. Multi-plexed. Cat.No. 6E2722	<b>BARREL KIT #28</b> A DIGIT READOUTS 10 for \$1.98 Bargain of a lifetime! All we got was 1 barrel—the "blister digit" types. Multi-plexed. Cat.No. 6E2722	<b>BARREL KIT #27</b> NATIONAL IC BONANZA HOBBY LENS 100 for \$1.98 Types 4000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linear, etc. All marked. Cat.No. 6E2860	<b>BARREL KIT #26</b> LITRONICS LED READOUTS 10 for \$1.98 717's, 727's, singles, tri-plex, etc. 33 to 0.6. But from factory, lot mixed, have fun! No. 6E2861	<b>BARREL KIT #25</b> NATIONAL IC BONANZA HOBBY LENS 100 for \$1.98 Types 4000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linear, etc. All marked. Cat.No. 6E2860	<b>BARREL KIT #24</b> 2 WATERS 100 for \$1.98 Suppliers throw 'em in the barrel. It's a 1/4 good mine. All marked. Cat.No. 6E2735	<b>BARREL KIT #23</b> MIXED READOUTS 10 for \$1.98 Factory returns—such numbers as MAN-4's, MAN-7's, MAN-3's, 11 barrels & no time to separate. Cat.No. 6E2733 Untested.	<b>BARREL KIT #22</b> PNP HIGH-POWER TRANSISTORS 20 for \$1.98 Popular germanium TO-3 case. 6E2614 100% good	<b>BARREL KIT #21</b> METALLIC RESISTORS 100 for \$1.98 Made mostly by Corning, the finest resistor made. Mostly 1/2 watters. 1% to 5% tol. & a barrel of values. Cat.No. 6E2609	<b>BARREL KIT #20</b> LONG LEAD DISCS 100 for \$1.98 "Auction sale!" Prime, marked only. Long leads. Cat.No. 6E2598 100% good	<b>BARREL KIT #19</b> POLYSTYRENE CAPS 100 for \$1.98 Finest caps made. As a gamble we bought 10 barrels from factory, mixed values. All good. Cat.No. 6E2729	<b>BARREL KIT #18</b> DIPPED MYLARS 60 for \$1.98 Finest capacitors made, shiny finish. Imagine factory dumping 'em in barrels. Cat.No. 6E2597 100% good	<b>BARREL KIT #17</b> ROOMS-REGISTERS 75 for \$1.98 Unmarked 2K to 40 pin devices, marked internal factory numbers, to Cat.No. 6E2424	<b>BARREL KIT #16</b> SWITCHING DIODES 100 for \$1.98 Imagine famous switching diodes at these prices! Cat.No. 6E2418 Untested.	<b>BARREL KIT #15</b> RECTIFIERS 100 for \$1.98 1N1000 series. May include 25, 50, 100, 200, 400, 600, 800 and 1000 voltages. Cat.No. 6E2417	<b>BARREL KIT #14</b> SCRS, TRIACS, QUADRACS 40 for \$1.98 Raw factory stock. All the 10 amp types. Cat.No. 6E2419 Untested.	<b>BARREL KIT #13</b> DIODES 100 for \$1.98 Singles, duals, variety of values, styles, big ones & small ones. Cat.No. 6E2421	<b>BARREL KIT #</b>
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## CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33 U	\$5.95
CY2A	2.000 MHz	HC33 U	\$5.95
CY3A	4.000 MHz	HC18 U	\$4.95
CY7A	5.000 MHz	HC18 U	\$4.95
CY12A	10.000 MHz	HC18 U	\$4.95
CY14A	14.31818 MHz	HC18 U	\$4.95
CY19A	18.000 MHz	HC18 U	\$4.95
CY22A	20.000 MHz	HC18 U	\$4.95
CY30B	32.000 MHz	HC18 U	\$4.95

XR-2206KB Kit \$27.00 Special XR-2206KA Kit \$17.00

## EXAR

WAVEFORM GENERATORS	THIMERS
XR-205 \$8.40	XR-555CP 1.55
XR-2206CP 4.49	XR-555CP 1.85
XR-2207CP 3.85	XR-2240CP 3.25

MISCELLANEOUS

XR-2211CP \$6.70	PHASE LOCKED LOOPS
XR-1310CP \$3.20	XR-1488 3.65
XR-1310EP 3.20	XR-1488 5.80
XR-1800P 3.20	XR-210 5.20
XR-2567 2.99	XR-1489 4.80
	XR-567CP 1.95
	XR-567CT 1.70

## CONNECTORS

### PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out  
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	\$1.95
18/36	PINS (Solder Eyelet)	\$2.49
22/44	PINS (Solder Eyelet)	\$2.95
50/100 (1.00 Spacing)	PINS (Solder Eyelet)	\$6.95

25 PIN-D SUBMINATURE

DB25P	PLUG	\$3.25
DB25S	SOCKET	\$4.95

## IMC 3 1/2 DIGIT DVM KIT

This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3 1/2 digit DVM chip set. It has a 4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

**A. 0-2V DVM with Case \$49.95**  
**B. 5V Power Supply \$14.95**

## VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire. It is a self contained replaceable bobbin onto component leads or terminals installed on pre punched P Pattern Vectorboard. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire.

**SPECIAL \$7.95**

## REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg 3	250 ft 36 AWG GREEN	\$2.40
W36-3-B-Pkg 3	250 ft 36 AWG RED	\$2.40
W36-3-C-Pkg 3	250 ft 36 AWG CLEAR	\$2.40
W36-3-D-Pkg 3	250 ft 36 AWG BLUE	\$2.40

## 1/16 VECTOR BOARD

Part No.	0.1" Hole Spacing	P-Pattern	W	L	1	2-Up
PHENOLIC	64P44 062XXP	4.50	6.50	1.7	1.54	
	169P44 02XXP	4.50	17.00	.69	3.42	
EPOXY GLASS	64P44 062	4.50	6.50	2.0	1.85	
	169P44 062	4.50	8.50	2.36	2.31	
	169P44 062	4.50	17.00	5.04	4.50	
EPOXY GLASS COPPER CLAD	169P44 062	8.50	17.00	9.23	8.26	
	169P44 062C1	4.50	17.00	6.80	6.12	

## HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO 5	\$ .25
291-36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	\$ .25
680-75A	Black Anodized Aluminum	\$1.60

## HEXADECIMAL ENCODER 19-KEY PAD

• 1 0  
• ABCDEF  
• Return Key  
• Optional Key (Period)  
• — Key

**\$10.95 each**

## 63 KEY KEYBOARD

This keyboard features 63 unique coded SPST keys, unaffected to any kind of P.C.B. A very solid molded plastic 13 x 4 base suits most applications.

**\$19.95**

H00185 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER \$7.95

## JOYSTICK

These joysticks feature 4\* potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastic components only at the movable joint. Perfect for electronic games and instrumentation.

Special **\*5K Pots \$4.95**  
**\*100K Pots \$7.95**

## MICROPROCESSOR COMPONENTS

8080A CPU	\$19.95	8228 System Controller - Bus Driver	\$10.95
8212 8 Bit Input/Output	4.95	MC6800L 8 Bit MPU	35.00
8214 Priority Interrupt Control	15.95	MC6820L Periph. Interface Adapter	15.00
8216 Bi-Directional Bus Driver	6.95	MC6810AP1 128 x 8 Static RAM	6.00
8224 Clock Generator/Driver	10.95	MC6830L7 1024 x 8 Bit ROM	18.00
CDP1802 - with user manual	39.95	Z80 CPU	49.95

CPU S	RAM S		
8080A Super 8008	24.95	1101 256 x 1 Static	\$ 1.49
8085A Super 8008	19.95	2101 256 x 4 Static	5.95
		2102 1024 x 1 Static	1.75
		2107 5280 4096 x 1 Dynamic	4.95
		2111 256 x 4 Static	6.95
		2114 16 x 4 Static	6.95
		2115 256 x 4 Static	6.95
		2116 16 x 4 Static	1.49
		2117 256 x 4 Static	2.25
		2118 16 x 4 Static	6.95
		2119 256 x 4 Static	2.95
		2120 16 x 4 Static	2.95
		2121 256 x 4 Static	2.95
		2122 16 x 4 Static	2.95
		2123 256 x 4 Static	2.95
		2124 16 x 4 Static	2.95
		2125 256 x 4 Static	2.95
		2126 16 x 4 Static	2.95
		2127 256 x 4 Static	2.95
		2128 16 x 4 Static	2.95
		2129 256 x 4 Static	2.95
		2130 16 x 4 Static	2.95
		2131 256 x 4 Static	2.95
		2132 16 x 4 Static	2.95
		2133 256 x 4 Static	2.95
		2134 16 x 4 Static	2.95
		2135 256 x 4 Static	2.95
		2136 16 x 4 Static	2.95
		2137 256 x 4 Static	2.95
		2138 16 x 4 Static	2.95
		2139 256 x 4 Static	2.95
		2140 16 x 4 Static	2.95
		2141 256 x 4 Static	2.95
		2142 16 x 4 Static	2.95
		2143 256 x 4 Static	2.95
		2144 16 x 4 Static	2.95
		2145 256 x 4 Static	2.95
		2146 16 x 4 Static	2.95
		2147 256 x 4 Static	2.95
		2148 16 x 4 Static	2.95
		2149 256 x 4 Static	2.95
		2150 16 x 4 Static	2.95
		2151 256 x 4 Static	2.95
		2152 16 x 4 Static	2.95
		2153 256 x 4 Static	2.95
		2154 16 x 4 Static	2.95
		2155 256 x 4 Static	2.95
		2156 16 x 4 Static	2.95
		2157 256 x 4 Static	2.95
		2158 16 x 4 Static	2.95
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		2161 256 x 4 Static	2.95
		2162 16 x 4 Static	2.95
		2163 256 x 4 Static	2.95
		2164 16 x 4 Static	2.95
		2165 256 x 4 Static	2.95
		2166 16 x 4 Static	2.95
		2167 256 x 4 Static	2.95
		2168 16 x 4 Static	2.95
		2169 256 x 4 Static	2.95
		2170 16 x 4 Static	2.95
		2171 256 x 4 Static	2.95
		2172 16 x 4 Static	2.95
		2173 256 x 4 Static	2.95
		2174 16 x 4 Static	2.95
		2175 256 x 4 Static	2.95
		2176 16 x 4 Static	2.95
		2177 256 x 4 Static	2.95
		2178 16 x 4 Static	2.95
		2179 256 x 4 Static	2.95
		2180 16 x 4 Static	2.95
		2181 256 x 4 Static	2.95
		2182 16 x 4 Static	2.95
		2183 256 x 4 Static	2.95
		2184 16 x 4 Static	2.95
		2185 256 x 4 Static	2.95
		2186 16 x 4 Static	2.95
		2187 256 x 4 Static	2.95
		2188 16 x 4 Static	2.95
		2189 256 x 4 Static	2.95
		2190 16 x 4 Static	2.95
		2191 256 x 4 Static	2.95
		2192 16 x 4 Static	2.95
		2193 256 x 4 Static	2.95
		2194 16 x 4 Static	2.95
		2195 256 x 4 Static	2.95
		2196 16 x 4 Static	2.95
		2197 256 x 4 Static	2.95
		2198 16 x 4 Static	2.95
		2199 256 x 4 Static	2.95
		2200 16 x 4 Static	2.95

## SPECIAL REQUESTED ITEMS

AV 3 8500 1	\$19.95	CD4508	6.75	82S115	25.00	3341	6.95
MC3061P	3.50	CD4515	6.50	5841	9.95	3368	3.95
MC4016P (74416)	7.50	CD4520	2.70	MC5024D	17.50	MC1488L7	4.95
MC14585	3.50	CD4521	17.50	11C90	19.95	LD110 LD111	25.00 set
MC14562	14.50	MC66571	17.50	D50076CH	3.75	AY-5-9100	17.50 set
CD4059	9.95	MC66574	17.50	TIL308	10.50	95H60	11.95
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## PARATRONICS

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### Logic Analyzer Kit

**MODEL 100A \$189.00/Kit**

- Analyzes any type of digital system
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Other CS Proto Boards

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PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6 1/2 x 2 3/4	75.00
PB203A - 9.75 x 6 1/2 x 2 3/4 120.00	

(includes power supply)

**Logic Monitor \$84.95**  
for TTL, TTL or CMOS Devices

**PROTO CLIPS**

14 PIN	\$4.50
16 PIN	4.75
24 PIN	8.50

**DESIGN MATES**

DM1 - Circuit Designer	\$4.95
DM2 - Function Generator	69.95
DM3 - RC Bridge	59.95

## QT PROTO STRIPS

Part No.	QTY	holes	price
QT-595	590	12.50	
QT-598	bus strip	2.50	
QT-475	470	10.90	
QT-478	bus strip	2.25	
QT-355	350	8.50	
QT-358	bus strip	2.00	
QT-185	180	4.75	
QT-125	120	3.75	
QT-85	80	3.25	
QT-75	70	3.00	

Experimenter 300 \$ 9.95  
Experimenter 600 \$10.95

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• Large Red Led Display  
• 1.8" high  
• AM PM Indicator  
• Seconds display at touch of button  
• Power failure indicator  
• One year factory warranty

C-500 - Ivory Case  
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C-5211  
Woodgrain Case  
**\$19.95**

## DIGITAL AUTO INSTRUMENT

SEVEN DIFFERENT INSTRUMENTS!  
MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS.

Please specify which one of the seven models you want when ordering — these do not all come in one unit. Each model must be bought separately.

1. TACHOMETER 0-9900 RPM 4, 6 or 8 Cylinders	4. SPEEDOMETER* 0-99 MPH
2. WATER TEMP. 100-250° F	5. OIL PRESSURE 0-80 PSI
3. FUEL LEVEL Percentage Low Fuel Indicator	6. OIL TEMP 200-350° F
	7. BATTERY MONITOR -1 Vols From 11-15 VDC

**BRIGHT YELLOW ORANGE .3" LED DISPLAY!**

Kit includes case, bracket and all components — complete.  
Nothing else to buy! 12 Volt NEG GND.  
DIMENSIONS: 4 1/2 x 4 x 2  
\*Add \$10.00 for required speed transducer.

**KIT: \$49.95**  
**ASSEMBLED: \$59.95**

## DIGITAL STOPWATCH

• Bright 6 Digit LED Display  
• Times to 99 minutes 59.99 seconds  
• Crystal Controlled Time Base  
• Three Stopwatches in One  
• Times Single Event — Split & Taylor  
• Sum 4.5" x 2.15" x .90" (4 1/2 ounces)  
• Uses 3 Penrite Cells

**Kit — \$39.95**  
**Assembled — \$49.95**  
**Heavy Duty Carry Case \$5.95**

**Stop Watch Chip Only (7205) \$19.95**

## ELECTRONIC 'PENDULUM' CLOCK

• Swing Pendulum  
• 7" Hours and Minutes Display  
• 12 or 24 Hour Mode  
• Time Set Push Buttons  
• Alarm Feature

Kit-unfinished (case unassembled) **\$59.95**  
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## QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

Elapsed Timer: Hrs, Mins and Secs  
12 or 24 Hr Capacity  
Simple Reset - Start Pushbutton Control

Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip. Large 4" LED's. Accuracy better than .1 min per mo. internal battery backup. 12 volt non-polar operation.

DIMENSIONS: 4 1/2 x 4 x 2"  
12 or 24 HOUR MODE

**Kit: \$29.95**  
**Assembled: \$39.95**

**CASE ONLY (includes hardware, mounting bracket and bezel) \$6.50**

## JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6 x 2 1/2 x 1 1/2 inches. A MM5314 clock chip.

115 VAC  
**\$17.95**

## DIGITAL CLOCK KIT — 3 1/2 INCH DIGITS

4 DIGIT KIT \$49.95  
4 DIGIT ASSEMBLED \$59.95  
6 DIGIT KIT \$69.95  
6 DIGIT ASSEMBLED \$79.95

This clock features big 3 1/2" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 21 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3 1/2" x 1 1/2" and the 4 digit is 18" x 3 1/2" x 1 1/2". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

## JE803 PROBE

The Logic Probe is a unit which is for the most part indispensable in trouble shooting logic families: TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test drawing a scant 10 mA max. It uses a MM5314 readout indicator, of the following states: by these symbols: (H) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can be used at MOS levels or circuit damage will result.

**\$9.95 Per Kit**  
printed circuit board

**T2L 5V 1A Supply**  
This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP current at 5 volts. We try





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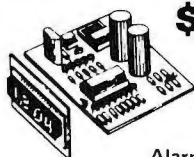
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### Disc Cap Assortment

PC leads. At  
least 10 different  
values. Includes  
.001, .01, .05,  
plus other stan-  
dard values.  
60/\$1.00

**\$9.95 KIT**

P.C. Board - 3.00  
AC XFMR - 1.50

Do not confuse with Non-Alarm  
kits sold by our competition!  
Eliminate the hassle -  
avoid the 5314!

### SIX DIGIT ALARM CLOCK KIT

We made a fantastic kit even better. Redesigned to take advantage of the latest advances in I.C. clock technology. Features: Litronix Dual 1/2" displays, Mostek 50250 super clock chip, single I.C. segment driver, SCR digit drivers. Greatly simplified construction. More reliable and easier to build. Kit includes all necessary parts (except case). P.C.B. or XFMR optional. **NEW! WITH JUMBO LED READOUTS!**

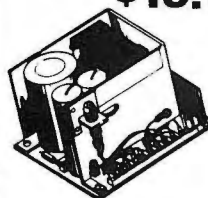
Motorola SCR  
2N4443. 8 AMP 400 PIV.  
P.C. Leads 3/\$1.

FAIRCHILD - TBA 641  
4W. Audio power Amp. Just  
out! In special heat sink  
DIP. One super audio IC.  
**\$1.50** with data

FND-359 -Led Readout  
.4 IN. Common Cathode.  
High efficiency. Has FND-  
70 PIN OUT. 79c

OUR CATALOG  
is chocked full of rare parts  
bargains, deals, RAM or CPU  
kits, plus much more. Yours  
**FREE!**

PRICES SHOWN SUBJECT  
TO CHANGE WITHOUT  
NOTICE.



**\$15.95**

### COMPUTER POWER SUPPLY

A very fortunate purchase. One of the best industrial quality REGULATED supplies we have seen. High performance, small size. Input is 120 VAC 60 HZ. Has the following regulated outputs: -5VDC@800MA; -15VDC @ 1.25 AMP; -25VDC @ 180 MA. Sold at a fraction of original cost. Do yourself a favor and order NOW. We expect a quick sellout.

### AMD - 1702A

Factory Prime Units. Brand New.  
1.5 micro-seconds access time.

**\$4.95 each. HUGE FACTORY DIRECT PURCHASE!**

Terms: Money back guarantee.  
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ders under \$10. add 75c.  
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Master Charge order in on our  
continental United States  
toll free Watts:

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Texas Residents Call Collect:  
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Special Thanks to:  
Dennis, Fred, Abe, Bill, Sam,  
Hal, Tom, Alex, John, Ely,  
and Larry

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P.O. BOX 28810 **D**  
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ORDERS OVER \$15.00 - CHOOSE \$1.00 FREE MERCHANDISE





# DIGI-KEY CORPORATION

## Quality Electronic Components

### DON'T FORGET OUR DISCOUNTS WHEN COMPARING PRICES

#### PRICE BREAKTHROUGH ON 74LS's

74LS00	28	74LS30	28	74LS90	57	74LS157	25	74LS248	79
74LS01	28	74LS32	33	74LS92	57	74LS158	75	74LS249	79
74LS02	28	74LS33	33	74LS93	57	74LS160	1.02	74LS253	84
74LS03	28	74LS34	33	74LS94	57	74LS161	1.02	74LS257	75
74LS04	29	74LS35	33	74LS95	57	74LS162	1.02	74LS258	75
74LS05	29	74LS36	33	74LS96	57	74LS163	1.02	74LS259	79
74LS06	29	74LS37	33	74LS97	57	74LS164	1.02	74LS263	79
74LS07	29	74LS38	33	74LS98	57	74LS165	1.14	74LS290	65
74LS08	29	74LS39	33	74LS99	57	74LS166	1.14	74LS293	65
74LS09	29	74LS40	33	74LS100	57	74LS167	1.14	74LS296	65
74LS10	28	74LS41	33	74LS101	57	74LS168	1.14	74LS297	65
74LS11	28	74LS42	33	74LS102	57	74LS169	1.14	74LS298	65
74LS12	28	74LS43	33	74LS103	57	74LS170	1.34	74LS353	67
74LS13	28	74LS44	33	74LS104	57	74LS171	1.34	74LS366	67
74LS14	28	74LS45	33	74LS105	57	74LS172	1.34	74LS367	67
74LS15	28	74LS46	33	74LS106	57	74LS173	1.34	74LS368	67
74LS16	28	74LS47	33	74LS107	57	74LS174	1.06	74LS369	67
74LS17	28	74LS48	33	74LS108	57	74LS175	1.06	74LS370	67
74LS18	28	74LS49	33	74LS109	57	74LS176	1.06	74LS371	67
74LS19	28	74LS50	33	74LS110	57	74LS177	1.06	74LS372	67
74LS20	28	74LS51	33	74LS111	57	74LS178	1.06	74LS373	67
74LS21	28	74LS52	33	74LS112	57	74LS179	1.06	74LS374	67
74LS22	28	74LS53	33	74LS113	57	74LS180	1.06	74LS375	67
74LS23	28	74LS54	33	74LS114	57	74LS181	1.06	74LS376	67
74LS24	28	74LS55	33	74LS115	57	74LS182	1.06	74LS377	67
74LS25	28	74LS56	33	74LS116	57	74LS183	1.06	74LS378	67
74LS26	28	74LS57	33	74LS117	57	74LS184	1.06	74LS379	67
74LS27	28	74LS58	33	74LS118	57	74LS185	1.06	74LS380	67
74LS28	28	74LS59	33	74LS119	57	74LS186	1.06	74LS381	67
74LS29	28	74LS60	33	74LS120	57	74LS187	1.06	74LS382	67
74LS30	28	74LS61	33	74LS121	57	74LS188	1.06	74LS383	67
74LS31	28	74LS62	33	74LS122	57	74LS189	1.06	74LS384	67
74LS32	28	74LS63	33	74LS123	57	74LS190	1.06	74LS385	67
74LS33	28	74LS64	33	74LS124	57	74LS191	1.06	74LS386	67
74LS34	28	74LS65	33	74LS125	57	74LS192	1.06	74LS387	67
74LS35	28	74LS66	33	74LS126	57	74LS193	1.06	74LS388	67
74LS36	28	74LS67	33	74LS127	57	74LS194	1.06	74LS389	67
74LS37	28	74LS68	33	74LS128	57	74LS195	1.06	74LS390	67
74LS38	28	74LS69	33	74LS129	57	74LS196	1.06	74LS391	67
74LS39	28	74LS70	33	74LS130	57	74LS197	1.06	74LS392	67
74LS40	28	74LS71	33	74LS131	57	74LS198	1.06	74LS393	67
74LS41	28	74LS72	33	74LS132	57	74LS199	1.06	74LS394	67
74LS42	28	74LS73	33	74LS133	57	74LS200	1.06	74LS395	67
74LS43	28	74LS74	33	74LS134	57	74LS201	1.06	74LS396	67
74LS44	28	74LS75	33	74LS135	57	74LS202	1.06	74LS397	67
74LS45	28	74LS76	33	74LS136	57	74LS203	1.06	74LS398	67
74LS46	28	74LS77	33	74LS137	57	74LS204	1.06	74LS399	67
74LS47	28	74LS78	33	74LS138	57	74LS205	1.06	74LS400	67
74LS48	28	74LS79	33	74LS139	57	74LS206	1.06	74LS401	67
74LS49	28	74LS80	33	74LS140	57	74LS207	1.06	74LS402	67
74LS50	28	74LS81	33	74LS141	57	74LS208	1.06	74LS403	67
74LS51	28	74LS82	33	74LS142	57	74LS209	1.06	74LS404	67
74LS52	28	74LS83	33	74LS143	57	74LS210	1.06	74LS405	67
74LS53	28	74LS84	33	74LS144	57	74LS211	1.06	74LS406	67
74LS54	28	74LS85	33	74LS145	57	74LS212	1.06	74LS407	67
74LS55	28	74LS86	33	74LS146	57	74LS213	1.06	74LS408	67
74LS56	28	74LS87	33	74LS147	57	74LS214	1.06	74LS409	67
74LS57	28	74LS88	33	74LS148	57	74LS215	1.06	74LS410	67
74LS58	28	74LS89	33	74LS149	57	74LS216	1.06	74LS411	67
74LS59	28	74LS90	33	74LS150	57	74LS217	1.06	74LS412	67
74LS60	28	74LS91	33	74LS151	57	74LS218	1.06	74LS413	67
74LS61	28	74LS92	33	74LS152	57	74LS219	1.06	74LS414	67
74LS62	28	74LS93	33	74LS153	57	74LS220	1.06	74LS415	67
74LS63	28	74LS94	33	74LS154	57	74LS221	1.06	74LS416	67
74LS64	28	74LS95	33	74LS155	57	74LS222	1.06	74LS417	67
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74LS67	28	74LS98	33	74LS158	57	74LS225	1.06	74LS420	67
74LS68	28	74LS99	33	74LS159	57	74LS226	1.06	74LS421	67
74LS69	28	74LS100	33	74LS160	57	74LS227	1.06	74LS422	67
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74LS73	28	74LS104	33	74LS164	57	74LS231	1.06	74LS426	67
74LS74	28	74LS105	33	74LS165	57	74LS232	1.06	74LS427	67
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74LS77	28	74LS108	33	74LS168	57	74LS235	1.06	74LS430	67
74LS78	28	74LS109	33	74LS169	57	74LS236	1.06	74LS431	67
74LS79	28	74LS110	33	74LS170	57	74LS237	1.06	74LS432	67
74LS80	28	74LS111	33	74LS171	57	74LS238	1.06	74LS433	67
74LS81	28	74LS112	33	74LS172	57	74LS239	1.06	74LS434	67
74LS82	28	74LS113	33	74LS173	57	74LS240	1.06	74LS435	67
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74LS84	28	74LS115	33	74LS175	57	74LS242	1.06	74LS437	67
74LS85	28	74LS116	33	74LS176	57	74LS243	1.06	74LS438	67
74LS86	28	74LS117	33	74LS177	57	74LS244	1.06	74LS439	67
74LS87	28	74LS118	33	74LS178	57	74LS245	1.06	74LS440	67
74LS88	28	74LS119	33	74LS179	57	74LS246	1.06	74LS441	67
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74LS90	28	74LS121	33	74LS181	57	74LS248	1.06	74LS443	67
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74LS96	28	74LS127	33	74LS187	57	74LS254	1.06	74LS449	67
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74LS101	28	74LS132	33	74LS192	57	74LS259	1.06	74LS454	67
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74LS107	28	74LS138	33	74LS198	57	74LS265	1.06	74LS460	67
74LS108	28	74LS139	33	74LS199	57	74LS266	1.06	74LS461	67
74LS109	28	74LS140	33	74LS200	57	74LS267	1.06	74LS462	67
74LS110	28	74LS141	33	74LS201	57	74LS268	1.06	74LS463	67
74LS111	28	74LS142	33	74LS202	57	74LS269	1.06	74LS464	67
74LS112	28	74LS143	33	74LS203	57	74LS270	1.06	74LS465	67
74LS113	28	74LS144	33	74LS204	57	74LS271	1.06	74LS466	67
74LS114	28	74LS145	33	74LS205	57	74LS272	1.06	74LS467	67
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74LS116	28	74LS147	33	74LS207	57	74LS274	1.06	74LS469	67
74LS117	28	74LS148	33	74LS208	57	74LS275	1.06	74LS470	67
74LS118	28	74LS149	33	74LS209	57	74LS276	1.06	74LS471	67
74LS119	28	74LS150	33	74LS210	57	74LS277	1.06	74LS472	67
74LS120	28	74LS151	33	74LS211	57	74LS278	1.06	74LS473	67
74LS121	28	74LS152	33	74LS212	57	74LS279	1.06	74LS474	67
74LS122	28	74LS153	33	74LS213	57	74LS280	1.06	74LS475	67
74LS123	28	74LS154	33	74LS214	57	74LS281	1.06	74LS476	67
74LS124	28	74LS155	33	74LS215	57	74LS282	1.06	74LS477	67
74LS125	28	74LS156	33	74LS216	57	74LS283	1.06	74LS478	67
74LS126	28	74LS157	33	74LS217	57	74LS284	1.06	74LS479	67
74LS127	28	74LS158	33	74LS218	57	74LS285	1.06	74LS480	67
74LS128	28	74LS1							



## SPECIAL PRICING!

PRIME - HIGH SPEED RAM

# 21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24 \$1.95 ea 100-199 \$1.60 ea  
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OVER 500 PCS. **1.39** ea.

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.

Specify for 7001 **B, Cor X - \$7.95**

## 6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME -

29-30-31 DAY CALENDAR. ALARM, SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT - 7001B WITH 6-.5" DIGITS ..... \$39.95

KIT - 7001C WITH 4-.6" DIGITS &

2-.3" DIGITS FOR SECONDS ..... \$42.95

KIT - 7001X WITH 6-.6" DIGITS ..... \$45.95

KITS ARE COMPLETE (LESS CABINET)

ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1



## 6 DIGIT LED CLOCK KIT #850-4

12/24 HR. OPERATION BIG .4" DIGITS - 50/60 HZ OPERATION.

KIT INCLUDES

- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 HZ OPERATION
- 12 or 24 HR OPERATION

6 LED Readouts (FND-359 Red, com. cathode)

1. MM5314 Clock Chip (24 pin)

13 Transistors

5 Switches

6 Capacitors

5 Diodes

9 Resistors

24 Molex pins

"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

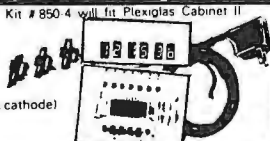
PRINTED CIRCUIT BOARD FOR KIT #850-4, SCREEN PRINTED

DRILLED AND SOLDER PLATED FIBERGLASS ..... \$2.95

MINI-BRITE RED LED'S (FOR COLOR IN CLOCK DISPLAY) ... Pkg. of 5-\$1.00

MOLDED PLUG TRANSFORMER 115/10 VAC (WITH CORD) ..... \$2.50

NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display.



\$1195 QTY. 1-5

\$1095 QTY. 6-11

\$995 QTY. 12 or MORE

## MOBILE LED CLOCK

12/24 HR. 4" DIGITS!

MODEL 12 VOLT AC or DC POWERED

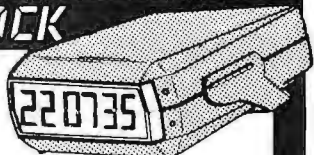
#2001

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY - TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY (Use When Key Off in Car, Etc.)
- TOP QUALITY PC BOARDS & COMPONENTS - EXCELLENT INSTRUCTIONS
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT 29<sup>95</sup> 3 OR MORE \$27<sup>95</sup> 115 VAC Power Pack #AC-1 \$25<sup>00</sup>

ASSEMBLED UNITS WIRED & TESTED (LESS 9V BATTERY) \$39<sup>95</sup> 3 OR MORE \$37<sup>95</sup>

WIRED FOR 12 HR. OP. IF NOT SPECIFIED OTHERWISE



60 HZ.

XTAL TIME BASE

Will enable

Digital Clock Kits

or Clock-Calendar

Kits to operate

from 12V DC.

1"x2" PC Board

Power Req: 5-15V

(2.5 MA. TYP.)

Easy 3 wire hookup

Accuracy: ± 2PPM

#TB-1 (Adjustable)

Complete Kit \$4<sup>95</sup>

W/ir & Cal \$9.95

25 AMP BRIDGE

\$1.95 ea

3/\$5.00

## PLEXIGLAS CABINETS

Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I

3"H, 6"W, 5 1/2"D Black, White or

CABINET II Clear Cover

2 1/2"H, 5"W, 4"D \$6.50 ea.

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS

3"x6"x1/8" 95<sup>ea</sup> 4/13

## SEE THE WORKS Clock Kit

Clear Plexiglas Stand

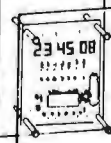
- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled

Kit #850-4 CP

Size: 6"H, 4 1/2"W, 3"D

\$23<sup>50</sup> ea. 2/45.



A SUPER CLOCK!

## JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring six .5" digits, MM5314 IC 12/24 Hr. time, 50/60 HZ., Plug Transformer, Line Cord, Switches, and all Parts. (Ideal Fit in Cabinet II) Kit # 5314-5

WITH PC Boards \$19<sup>95</sup> 2/38.

JUMBO DIGIT CONVERSION KIT \$9.95 ea.

Convert small digit LED clock to large 5" displays. Kit includes 6-

LED's, Multiplex PC Board & easy hookup info.

Kit # JD 1CC For common Cathode

Kit # JD 1CA for common Anode

## TELEPHONE FORMAT

KEYBOARD

BY Chromics

# EF-21360

2-1/4"x3"

5/32" thick

\$4.95

6/28.

15 VAC Power Pack #AC-1 \$25<sup>00</sup>

ASSEMBLED UNITS WIRED & TESTED (LESS 9V BATTERY) \$39<sup>95</sup> 3 OR MORE \$37<sup>95</sup>

WIRED FOR 12 HR. OP. IF NOT SPECIFIED OTHERWISE

## NEW LSI TECHNOLOGY

## FREQUENCY COUNTER KIT

8 LARGE .4" RED LED DIGITS

Kit #FC-50 • 8 IC's • XTAL TIME BASE

A truly "State of the Art" counter using quality components throughout.

KIT INCLUDES: DETAILED INSTRUCTIONS, XTAL, TOP QUALITY FIBERGLASS DOUBLE SIDED PC BOARD, IC'S WITH SOCKETS AND ALL PARTS LESS POWER SUPPLY AND CABINET.

50 MHZ COUNTER KIT #FC-50 \$69<sup>95</sup>

5 VOLT REGULATED 1 AMP POWER SUPPLY KIT #PS-02 \$9.95

350 MHZ PRESCALER KIT #PSL-350 23.95

650 MHZ PRESCALER KIT #PSL-650 \$29.95

CABINET (& MTG HARDWARE) #CAB III \$19.95

(CABINET WILL HOUSE #FC-50, #PS-02, AND A PRESCALER)

## Fairchild Super Digit

FND-359

4" Char. Ht. 7 segment LED

RED Com. Cath.

Direct alt replacement for popular FND-70.

95<sup>ea</sup> 10/\$8.50

100/\$79.00

SET OF 6 FND-359

WITH MULTIPLEX PC BOARD \$6.95

NYLON WIRE TIES

8" TIE WRAP 100/\$1.95

4" TIE WRAP 100/\$1.75

PLUG TRANSFORMERS

12 VAC at 150 MA \$ 2.50

12 VAC at 300 MA 3.50

7 VAC at 1.75 VA \$3.50

## SCHOTTKY TTL

74S00 \$ 35

74S01 40

74S04 55

74S05 60

74S09 35

74S10 40

74S20 45

74S40 45

74S50 45

74S51 55

74S60 85

74S64 55

74S74 85

74S78 1.75

74S78 1.50

74S86 95

74S107 95

74S112 95

74S113 1.40

74S114 95

74S133 75

74S134 75

74S138 1.75

74S141 1.50

74S151 1.95

74S153 1.95

74S155 1.95

74S156 1.95

74S157 1.80

74S158 2.50

74S174 2.50

74S175 2.50

74S181 2.95

74S182 1.95

74S251 2.75

DIGITAL CLOCK IC'S

MM5312 \$ 4.95

MM5314 3.95

MM5375 AB 3.95

CT 7001 7.95

CT 7002 13.95

MM5369 2.50

## PRESCALE

11C900C \$15.95

95H90 9.95

VOLTAGE REGULATORS

LM309H TO 5 \$ 95

LM309K TO 3 1.25

7805 TAB 95

7812 TAB 1.25

7812 TO 3 1.50

7815 TO 3 1.25

7815 TAB 1.25

7815 TO 5 .75

7824 TO 3 1.25

723 DIP .75

723 TO 5 .75

PROM

1702 E Prom \$8.95

5203 E Prom \$8.95

SPECIAL IC'S

7207A INTERSIL \$19.95

7208 INTERSIL \$ 4.95

MC14553 MOT \$ 9.95

MC14410 MDT \$12.50

2513 SIG \$ 9.95

IC SOCKETS

PINS 1-24 25 100

8 \$ 25 \$ 22 \$ 20

14 25 22 20

16 28 25 23

18 .31 28 26

24 .50 45 40

28 60 55 50

40 .75 70 65

XTAL

5.242880 MHZ. \$4.95

3.579545 MHZ. \$1.95

MOLEX PINS

\$9<sup>95</sup>

Reel of 1000

100 for \$1.25

## TRANSISTORS

2N2222 A TO 18 3/41 00

2N2172 TO 98 5 11 00

2N3415 TO 9 301 20

2N3704 TO 92 5 11 00

2N4400 TO 92 5 11 00

2N4129 TO 92 5 11 00

2N4249 TO 92 5 11 00

2N4437 TO 92 5 11 00

2N6027 PUT 2 11 00

2N5457 N J Fet 2 11 00

DIODES

IN 4002 1A 100 PIV 12/51 00

IN 4005 1A, 600 PIV 11/51 00

IN 4007 1A, 1000 PIV 10/51 00

RECTIFIER 2.5A, 1000 PIV 4/51 00

IN 914 SIL SIGNAL 20/51 00

IN 4148 SIL SIGNAL 20/51 00

28V. 4 51 00

LINEAR

555 TIMER 2/51 00

556 DUAL TIMER 95

565 PLL 1.75

566 FUNCTION GEN. 1.75

567 TONE DECODER 1.75

TRANSISTOR SOCKET

TO-5/18 GOLD PINS 5.51 00



## 7400 TTL

7400	21	7442	1.08	74121	55
7401	21	7448	1.15	74122	49
7402	21	7450	26	74123	1.05
7404	21	7451	27	74125	60
7405	24	7453	27	74126	81
7406	45	7454	41	74132	3.00
7407	45	7460	22	74141	1.15
7408	25	7472	39	74150	1.10
7409	25	7473	45	74151	1.25
7410	20	7474	45	74153	1.35
7411	30	7475	80	74154	1.25
7413	85	7482	1.75	74155	1.21
7416	43	7483	1.15	74157	1.30
7417	43	7485	1.12	74161	1.45
7420	21	7486	45	74164	1.65
7422	150	7489	2.49	74165	1.65
7423	43	7490	69	74166	1.70
7427	37	7491	120	74174	1.95
7428	33	7492	82	74175	1.95
7430	26	7493	82	74180	1.05
7432	31	7494	91	74181	3.55
7437	47	7495	91	74191	1.50
7438	40	7496	91	74195	1.00
7440	21	74100	1.25	74197	1.00
7441	110	74107	49	74298	1.30

## 74L SERIES TTL

74L00	33	74LS04	45	74LS113	98
74L10	33	74LS10	39	74LS138	1.89
74L30	33	74LS20	39	74LS174	2.50
74L42	150	74LS51	39	74LS386	5.50
74L86	69	74LS74	65	74LS153	2.25
74LS00	39	74LS112	65	74LS387	1.95

## 74H00 TTL

74H00	33	74H11	33	74H53	39
74H01	33	74H20	33	74H55	39
74H04	33	74H21	33	74H73	59
74H05	35	74H30	33	74H74	59
74H10	33	74H40	33	74H76	60

## ELECTROLYTIC CAPACITORS

22MF50	AXIAL LEADS	15
33MF10	AXIAL LEADS	15
33MF10	NO POLARITY	15
10MF25	AXIAL LEADS	15
10MF50	AXIAL LEADS	15
10MF150	AXIAL LEADS	20
25MF35	AXIAL LEADS	15
30MF25	AXIAL LEADS	15
47MF25	RADIAL LEADS	15
47MF50	RADIAL LEADS	20
100MF16	RADIAL LEADS	15
100MF25	RADIAL LEADS	20
500MF50	AXIAL LEADS	65
1000MF35	AXIAL LEADS	65

## 5400 SERIES

5400	100	5475	1.50
5404	125	5486	1.90
5410	100	5493	2.00
5426	125	54100	1.80
5473	150	54LS04	1.00

## C MOS

4001AE	29	4022AE	1.20
4002AE	29	4023AE	29
4007AE	29	4024AE	1.50
4009AE	58	4025AE	35
4010AE	58	4026AE	1.49
4011AE	29	4028AE	1.60
4012AE	29	4029AE	2.90
4013AE	52	4030AE	65
4015AE	1.25	4037AE	4.50
4016AE	65	4040AE	2.40
4018AE	1.10	4044AE	1.50
4019AE	65	4047AE	2.75
4020AE	1.75	4049AE	75
4021AE	1.50	4050AE	75

## MISC CIRCUITS

BC184L	60	LM309K	1.95
CA301	75	LM351A	70
CA3005	80	LM741CP	40
CA3006	110	LM1458M	65
CA3018	1.60	MFC9020	1.15
CA3018A	1.60	MR995A	1.05
CA3026	2.15	MSC9967P1	50
CA3035	2.45	N5558	55
CA3039	1.35	N8598B	5.00
CA3058	1.90	N5555V	45
CK707P	45	PA771131	45
C5134J	1.15	PL994551	45
C5135J	1.20	RC14370B	35
C5136	1.25	SC9962P	70
IC313GE	1.50	SC9966P	1.25
LM301AN	35	SN15830N	50

## CARBON RESISTORS

Minimum 5 Pcs Per Value

QUANTITY	5-25	30-95	100-495
PRICING	06	05	04
W5%	08	07	06
STANDARD RESISTANCE VALUES	OHMS	270	820
10	270	820	4.7K
22	300	910	5.1K
47	330	1.0K	6.8K
51	470	1.5K	7.5K
100	510	2.2K	8.2K
150	560	2.7K	10K
220	680	3.3K	15K
240	750	3.9K	22K

## MOTOROLA CIRCUITS

MC725P	1.50	MC1741GG	98
MC740L	1.55	MC1804P	98
MC790P	1.50	MC1810P	98
MC832P	48	MC2053L	45
MC1004L	1.25	MC3004L	1.32
MC1008L	1.25	MC3006P	1.44
MC1010L	1.25	MC3007P	1.32
MC1011L	1.25	MC3021L	2.15
MC1036L	12.50	MC3021P	2.15
MC1037L	12.50	MC3060L	2.65
MC1352P	1.05	MC3062L	3.00
MC1406CP	3.95	MC4024P	2.20
MC1468L	2.90	MC14501CP	31
MC1469R	2.50	MC14502CP	1.18
MC1510G	8.00	MC14507CP	82
MC1514L	4.50	MC14510CP	2.40
MC1550G	1.50	MC14511CP	2.76
MC1558	4.37	MC14512CP	1.92
MC1595L	6.25	MC14519CG	94
MC1596G	3.31	MC14528CP	1.74
MC1723CG	1.25	MC4044P	4.80

## POSITIVE VOLTAGE REGULATORS

LM340K-5	1.95
LM340K-6	1.95
LM340K-8	1.95
LM340K-12	1.95
LM340K-15	1.95
LM340K-18	1.95
LM340K-24	1.95
LM340T0-5	1.75
LM340T0-6	1.75
LM340T0-8	1.75
LM340T0-12	1.75
LM340T0-15	1.75
LM340T0-18	1.75
LM340T0-24	1.75

## NEGATIVE REGULATORS AVAILABLE

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100 Asst. (includes Case T03, T066, T0220, T0202)		\$2.99
Diode Pac	100 Asst. (includes Case T05, T039, T018, D07, 0041)	
100 Asst. (includes 14 & 16 Pin)		\$3.50
Resistor Pac	50 Asst. (Assorted values)	\$1.50
Mos Fet Pac	10 Asst. (many top #s Case T072)	\$0.99
SCR Pac	100 Asst. (similar to C103 Series) Case to 92, VR 10-100V, 1.400MA, IGT-200MA	\$4.00

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1N60	.25	2N930	.25	2N2218A	.30	2N2907	.25	2N3730	2.50	2N4234	.95
1N270	.40	2N956	.30	2N2219	.25	2N2907A	.30	2N3731	3.75	2N4400	.16
1N914	.10	2N960	.90	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.16
2N173	1.75	2N967	.95	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.16
2N174	3.50	2N1136	1.75	2N2222	.25	2N3019	.50	2N3772	1.90	2N4403	.20
2N178	.90	2N1142	2.25	2N2223	.30	2N3053	.30	2N3819	.40	2N4410	.16
2N327A	1.15	2N1300	1.00	2N2223	1.00	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1301	1.10	2N2270	.40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	.90	2N1302	1.25	2N2323	1.00	2N3227	1.00	2N3866	.85	2N5064	.50
2N338A	1.05	2N1303	.70	2N2324	1.35	2N3247	3.40	2N3903	.16	2N5130	.20
2N398B	1.50	2N1304	1.25	2N2325	2.00	2N3250	.50	2N3904	.16	2N5138	.15
2N404	.75	2N1305	.75	2N2326	2.85	2N3375	6.50	2N3905	.16	2N5198	3.75
2N443	2.50	2N1306	1.35	2N2327	3.80	2N3393	.20	2N3906	.16	2N5198	3.75
2N456	1.30	2N1307	.75	2N2328	4.25	2N3394	.17	2N3925	3.75	2N5294	.50
2N501A	3.00	2N1308	1.50	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5296	.50
2N508A	.45	2N1309	.90	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	.75	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5354	.20
2N652A	1.25	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5369	.20
2N677	6.00	2N1557	1.15	2N2712	.18	2N3442	1.85	2N4036	.75	2N5400	.40
2N707	.25	2N1600	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5401	.50
2N708B	.75	2N1605	.35	2N2903	3.30	2N3563	.20	2N4049	.85	2N5457	.35
2N711	.90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1.10	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.16	2N5459	.30
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5461	.30
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.20	2N4142	.20	2N5462	.30
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.20	2N4143	.20	2N5463	.30

## SILICON UNIJUNCTIONS

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2N2646	.45	2N4893	.50
2N2647	.55	2N4894	.50
2N4851	.75	2N6027	.55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	.35
MU4891	.50	MU20	.40



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IC Socket 16 Pin DIL Pkg. of 1	.27ea.

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1N4003	.80	7.00
1N4004	.90	8.00
1N4005	1.00	9.00
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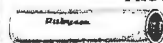
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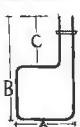
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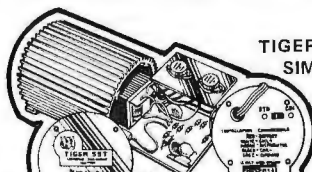
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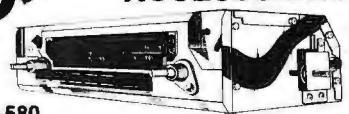
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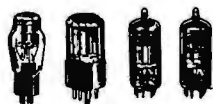
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7408	.18	7473	.35	74162 1.39
7409	.19	7474	.28	74163 1.09
7410	.16	7475	.48	74164 .99
7411	.25	7476	.30	74165 .99
7412	.43	7483	.68	74166 1.25
7413	.65	7485	.88	74170 2.10
7416	.35	7486	.40	74173 1.49
7417	.35	7489	2.25	74174 1.23
7420	.16	7490	.43	74175 .97
7422	.30	7491	.75	74176 .89
7423	.29	7492	.48	74177 .84
7425	.27	7493	.48	74180 .90
7426	.26	7494	.78	74181 2.45
7427	.29	7495	.79	74182 .79
7430	.20	7496	.79	74184 1.90
7432	.23	74100 .90	74185 2.20	
7437	.25	74105 .44	74187 5.75	
7438	.25	74107 .37	74190 1.15	
7440	.15	74121 .38	74191 1.25	
7441	.89	74122 .38	74192 .95	
7442	.59	74123 .65	74193 .85	
7443	.73	74125 .54	74194 1.25	
7444	.73	74126 .58	74195 .74	
7445	.73	74132 .89	74196 1.25	
7446	.81	74141 1.04	74197 .73	
7447	.79	74145 1.04	74198 1.73	
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305	.71	381	1.75	747 .71
307	.26	382	1.75	748 .35
308	.89	511	2.95	1458 .62
309K	1.35	540	2.95	1800 2.48
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311	.95	555	.45	7524 .71
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1201	1.39	560	3.39	8038 4.25
120K	1.39	562	3.39	8864 2.25
122	1.70	565	1.18	75150 1.75
124	1.52	566	1.95	75451 .35
339	1.58	567	1.95	75452 .35
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340T	1.49	710	.35	75491 .71
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4002A	.25	4021A	1.18	4069A .44
4006A	1.35	4022A	.94	4071A .26
4007A	.26	4023A	.25	4072A .35
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4012A	.25	4030A	.44	4518A 1.56
4014A	.45	4035A	1.27	4518A 1.56
4014A	1.27	4040A	1.39	4565A 2.10
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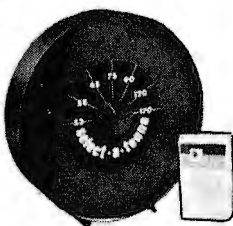


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**"Not the loudest sound in town, but the best quality" claims WXRT, Chicago, longtime Stanton user...**



Daniel Lee, President and General Manager, discussing Stylus Replacement Policy with Howard Williams, Chief Engineer and Ken Rasek, Audio Engineer.

WXRT is a progressive rock, FM station that is unique in many ways. Its whole operation, including Administration, Sales, Engineering, Programming, Broadcasting, Transmitting (even the tower itself), is located in one place . . . a highly unusual set-up for a major market.

In a market crowded with as many radio stations as Chicagoland, the excellence of sound can make or break the station, especially a station like WXRT . . . which plays no tapes . . . has no record commercials . . . and goes totally with disc-to-air and live copy.

Since WXRT uses no limiters and no compression to magnify the level of their signal, their turntables and cartridges are absolutely crucial to the quality of their sound.

For over 10 years, the station has used the Stanton product in its turntables. Today, it even uses the 681 Triple-E for disc-to-air playback and, although this stylus was not designed for back-cueing, the engineers and announcers report no problem (they even use them on their AM operation, WSBC).

Leading radio stations around the nation depend on Stanton 681 Calibration series cartridges, because they offer improved tracking at *all* frequencies . . . they achieve perfectly flat frequency response to beyond 20 kHz. Its stylus assembly, even though miniaturized, possesses greater durability than had been thought possible to achieve.

Each 681 Triple-E is guaranteed to meet its specifications within exacting limits, and each one boasts the most meaningful warranty possible . . . an individual calibration test result is packed with each unit.

Whether your usage involves recording, broadcasting or home entertainment, your choice should be the choice of the professionals . . . The Stanton 681.



John Bell hands new record to Scott McConnell.



Air personality, John Bell prepares to play a record.

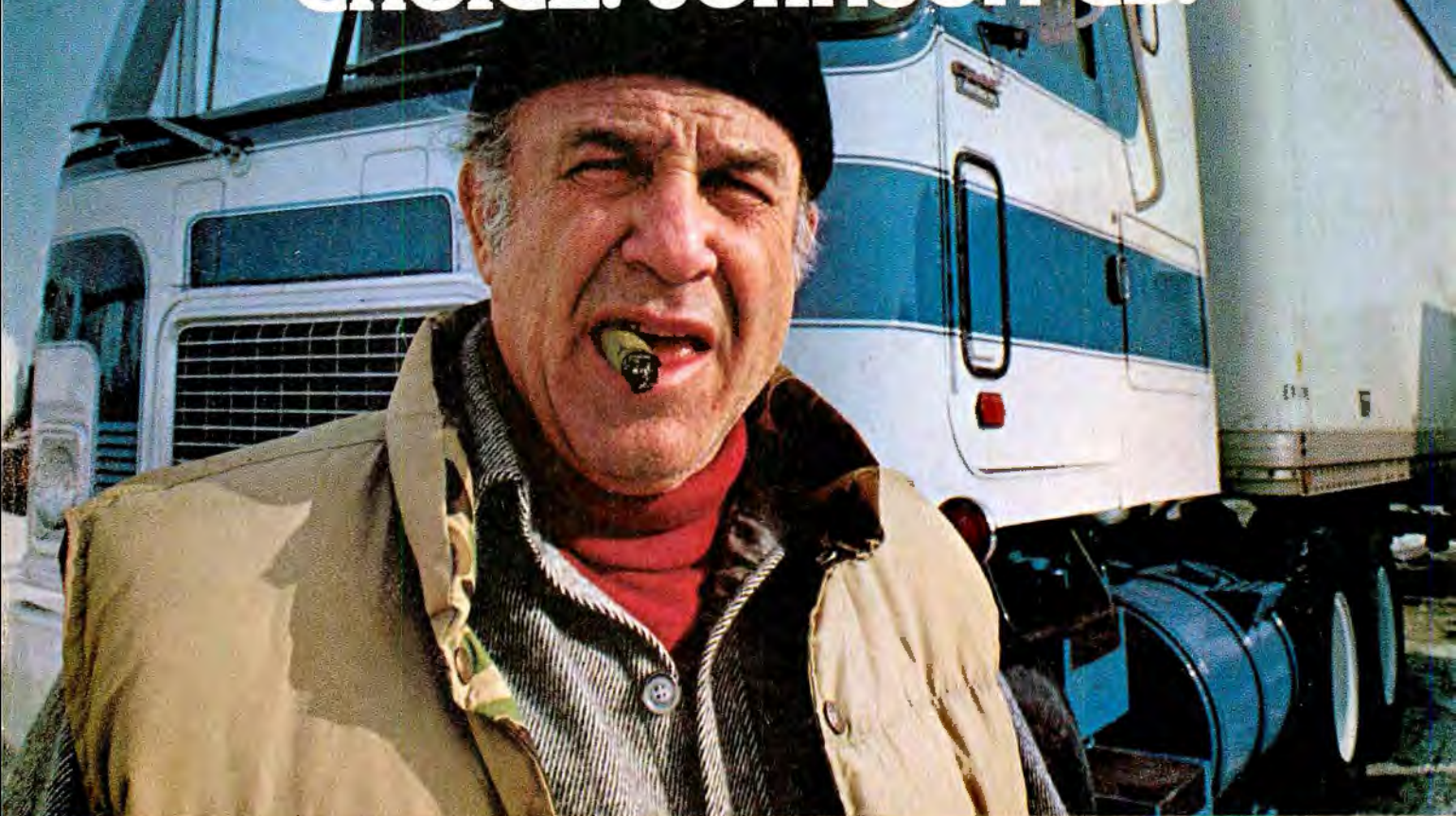
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\*Independent Trucker Survey results available upon request.



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